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GEOLOGICAL SURVEY OF CANADA

G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

ANNUAL REPORT

(NEW SERIES)

VOLUME VII

REPORTS A, B, C, F, J, M, R, S

1894

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY

1896

No. 581

To the Honourable

T. Mayne Daly, M.P.,

Minister of the Interior.

Sir,—I have the honour to submit herewith Volume VII. (New Series) of the Reports of the Geological Survey of Canada.

The volume comprises 1206 pages. It is accompanied by eleven maps and illustrated by fifteen plates and diagrams, besides a number of figures in the text.

The several parts composing the volume have been issued previously, as completed, and may be purchased separately at the prices noted on page ii.

I have the honour to be, Sir,

Your obedient servant,

GEORGE M. DAWSON,

Director.

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VOL. VII.

MAPS AND SECTIONS.

*In portfolio.

PLATES.

*In portfolio.

ERRATA.

Page 35 B., line 14 from top, *for* number *read* member.
" 37 B., first foot-note, *for* 1871–73 *read* 1871–72.
" 50 B., line 11 from bottom, *for* Belemite *read* Belemnite.
" 58 B., line 4 from bottom, *for* revolted *read* resulted.
" 114 B., foot-note, *for* p. 112 B *read* p. 111 B.
" 123 B., second foot-note, *for* 42 *read* 52.
" 129 B., line 15 from bottom, *for* from *read* form.
" 258 B., line 11 from bottom, *for* that *read* than.
" 51 M., No. 21, *for* Garry *read* Geary.
" 73 M., title of plate, *for* south-west, *read* south-east.
" 105 M., line 14 from bottom, *for* page 83 M. *read* pages 79–83 M.
" 109 M., first line, *for* north temparate *read* temperate.
" 128 M., line 24 from bottom, *for* sixty *read* fifty.
" 143 M., line 10 from bottom, *for* two hundred *read* one hundred.
" 143 M., line 9 from bottom, *for* two hundred *read* one hundred.
" 5 S., line 7 from bottom, *for* Tiles M, 100,000 *read* Tiles M, 19,000.
" 125 S., line 10 from bottom, *omit* "with a small proportion of mispickel."
" 184 S., line 6 from bottom *for* 190,000 *read* 19,000.

GEOLOGICAL SURVEY DEPARTMENT

G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1894

BY

THE DIRECTOR

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
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1895

No. 553

SUMMARY REPORT

ON THE

OPERATIONS OF THE GEOLOGICAL SURVEY

FOR THE YEAR 1894.

OTTAWA, 10th January, 1895.

The Hon. T. MAYNE DALY, M.P.,
Minister of the Interior.

SIR,—I have the honour to submit herewith the Annual Summary Report of the Geological Survey Department for the calendar year 1894. The work of the department has been successfully continued during the past year and some substantial progress has been made, although, in consequence of the reduced amount of money actually available for general purposes, the extent of the operations has had to be curtailed.

In this Summary Report it is intended to give, in accordance with the usual custom, a brief statement of the executive and office work of the department, together with somewhat more extended notices of the preliminary results of the various scientific investigations and explorations in the field. Such notices include the more notable points ascertained during the progress of the field work and especially those which appear to be of immediate economic importance. The systematic and detailed reports and maps of the several districts examined, which often take several years for their satisfactory completion, are published from time to time throughout the year, and in their collected form appear in a series of numbered volumes which constitute the principal and more permanent record of the work accomplished. Contents of this report.

The operations of the Geological Survey in the field, constitute the basis of the entire work of the department. These naturally divide themselves under two principal heads: (1) Reconnaissance surveys and Work of the Geological Survey.

Work of the Geological Survey.

explorations, covering in a general way large tracts of country, and (2) the systematic mapping and description in detail of less extensive areas. The first inevitably precedes the second class of work, and for many years it must, in the nature of things, remain the only method possible of dealing with the vast regions of Canada which lie beyond the boundaries of connected settlement. While the exploration of new districts, in which geographical information is obtained concurrently with data on the general geology and mineral resources, may attract popular attention to a greater degree, the methodical delineation of the geological features of the older parts of Canada must be regarded as at least equally important and as requiring no inferior ability or diligence on the part of those engaged in it.

Parties in the field.

During the year, Mr. A. P. Low's exploratory expedition in the Labrador Peninsula has been successfully completed, while Mr. J. B. Tyrrell has been engaged in a second expedition in the hitherto unknown country to the west of Hudson Bay and north of the Churchill River. In British Columbia, Ontario, Quebec, New Brunswick and Nova Scotia, the field work has been chiefly devoted to a continuation and extension of the investigations necessary for the regular series of map-sheets into which these provinces have been divided.

In consequence of the lack of money already alluded to, it was absolutely necessary to reduce the number of parties working in the field during the past season, as well as to diminish the amount accorded to the work in each district, thus decreasing the length of the field work. The total number of parties employed was twelve, as compared with sixteen during the previous season. It was not possible to invite the co-operation in the prosecution of the work of Abbé J. C. K. Laflamme of Quebec, Dr. F. D. Adams of Montreal, or Prof. L. W. Bailey, of Fredericton, a circumstance much to be regretted, as these gentlemen have in previous years contributed largely to the progress of the Survey.

The actual distribution of the field parties was as follows :—

British Columbia	2
North-west Territories (boring operations)	1
Keewatin District	1
Ontario	3
Quebec	1
Labrador Peninsula	1
New Brunswick	1
Nova Scotia	2
	12

Publications.

During the year the sixth volume of the new series of detailed reports of the Geological Survey has been printed, and it will shortly

be completed for issue. In selecting material for this volume, preference has been given to the statistical and other reports of which the value must depend largely upon prompt publication, while it has been found necessary to hold over a number of manuscript reports and maps, till a further appropriation for printing becomes available. The geological maps actually printed during the year, include eight sheets of the Nova Scotian series, on the scale of one mile to the inch, and one sketch-map of south-western Nova Scotia. Six additional sheets of the series first referred to, and the south-western sheet of the Eastern Townships series (Quebec) are well advanced and will shortly be printed. Publications.

The accumulation of material awaiting publication promises to constitute a source of embarrassment to the work of the Survey as a whole, and it is earnestly to be hoped that the means will soon be afforded to render it possible to give to the public these results of surveys and investigations already completed. Exclusive of the reports comprised in the sixth volume, above mentioned, and besides those now in course of completion by members of the staff, the manuscripts in hand will make, when printed, more than 700 pages; while about thirty-two separate maps are now ready to go to the engraver.

I may also again venture to direct your attention to the wholly inadequate accommodation afforded to the museum and offices by the present building on Sussex Street. The collections now contained in this building, including the departments of mineralogy, lithology, palæontology, botany, zoology and ethnology, either on exhibition or classified and readily accessible, aggregate more than 120,000 specimens. The greater part of the space available is devoted to the illustration of the minerals and general geology of Canada, but it is impossible to display the specimens to advantage, or in such a manner as to attract the public notice which they deserve. The position of the building and its construction, further render it liable to the constant danger of destruction by fire, and when it is remembered that the collections include the typical specimens which have been described in the publications of the Survey since its initiation, besides many others of a character which it would now be impossible to duplicate, the very serious nature of this risk will be understood. The building also contains much accumulated material in maps, plans, notes and records, together with the entire reserve stock of the printed reports of the Survey and a library comprising a large number of scarce and valuable scientific works. Museum.

Early in October, Dr. A. R. C. Selwyn, C.M.G., F.R.S., under whose direction so great an amount of important work has been car- Changes in staff.

Changes in staff.

ried on by the Geological Survey since the retirement of Sir W. E. Logan in 1869, obtained leave of absence, and on the 7th of January was granted his superannuation. Mr. T. C. Weston, whose connection with the Survey dates from 1857, was superannuated on August 1st. To Mr. Weston's assiduity and skill, the museum owes much, both in the matter of collections and arrangement.

The department has also suffered the loss of two members of the staff by death. Mr. Scott Barlow, geographer and chief draughtsman, died on March 29th, after nearly thirty-eight years of continuous and valuable work in the department. Mr. A. S. Cochrane, assistant topographer, died on December 2nd, after seventeen years of service. Some of the more important surveys made by Mr. Cochrane are described in the report for 1879-80 (p. 7 C.) Mr. Amos Bowman, who although but for a short time on the permanent staff, had been engaged for some years in the work of the Survey in British Columbia, particularly in the Cariboo mining district, died on June 18th. He was not at the time of his death in the employment of the department.

Boring at Athabasca Landing.

Experimental boring at Athabasca Landing.

The occurrence of great quantities of bitumen or maltha along a portion of the Athabasca River has long been known, having been noticed and commented upon by the very earliest travellers in the region. Beds of sand or very soft sandstone of Cretaceous age, varying from 140 to 225 feet in thickness, are there found to be more or less completely saturated with bitumen, for a distance of some ninety miles along the river. These beds are known as "tar sands." More recently a number of smaller occurrences of bitumen in the form of "tar springs," as well as sources of combustible gas, have been found at different places over a very extensive district. All these circumstances point to the probable existence of a great petroleum field, of which possibly some parts have already exhausted themselves in saturating the lowest Cretaceous sands, but of which probably the greater portion is still effectually sealed by the thick covering of overlying rocks. It is believed that the source of the petroleum which has given rise to the deposits of bitumen is in the Devonian strata, which here immediately underlie those of Cretaceous age.

In the search for petroleum of commercial value, in which the more volatile constituents may still be retained, two principal modes of its probable occurrence in quantity, present themselves :—(1) The "tar sands," at a distance from their outcrop and where sufficiently covered,

may contain reservoirs of such petroleum, secondarily derived ; (2) the original sources of the petroleum, probably existing in porous beds of the Devonian, may themselves be reached, after passing through the "tar sands" or their equivalents.

Athabasca boring—*Cont.*

Geological features.

In 1890, Mr. R. G. McConnell, of this Survey, made a careful examination of the geological conditions along the Athabasca and Peace Rivers and in the intervening country, with special reference to the presumed existence of an oil field.* He ascertained, with as much accuracy as possible from the natural outcrops, the thickness and lie of the shales and sandstones of the Cretaceous system by which the greater part of the region is covered. In his report he writes :—

"The tar sands evidence an upwelling of petroleum to the surface unequalled elsewhere in the world, but the more volatile and valuable constituents of the oil have long since disappeared, and the rocks from which it issued are probably exhausted, as the flow has ceased. In the extension of the tar sands under cover the conditions are different, and it is here that oils of economic value should be sought. In ascending the Athabasca, the tar sands are overlaid at Boiler Rapid by a cover of shales sufficient to prevent the oil from rising to the surface, and in ascending the river, this cover gradually thickens. * * * * The question of the continuity of the tar sands and their petroliferous character under cover, can, however, only be settled in a decided manner by boring, and it is highly desirable that drilling operations should be undertaken for this purpose. At the mouth of Pelican River, the tar sands are probably covered by about 700 feet of strata, and this amount increases as the river is ascended. At the Athabasca Landing, if the formation extends to that point, it probably lies at a depth of from 1,200 to 1,500 feet below the surface, but the distance of the Landing from the outcrop of the tar sands, and the variability in the thickness of the Cretaceous formations make it impossible to give more than a rough estimate."†

Arrangement for boring operations.

The importance of actually ascertaining by means of boring operations the existence or otherwise of economically valuable bodies of petroleum in the Athabasca region has been recognized for many years, but the remoteness of the region and the apparent impossibility of immediately utilizing any discoveries which might be made, have hitherto prevented the necessary experiments. The recent completion of a line of railway to Edmonton has, however, considerably changed the conditions in these respects. It was thus decided by you that the

*An earlier notice of the tar sand deposits by Prof. Macoun, and a preliminary geological description of the Athabasca by Dr. R. Bell will be found in Reports of Progress of the Geological Survey, 1875-76, p. 169, 1882-84, part CC.

†Annual Report Geological Survey of Canada, vol. V., (N.S.), p. 66 D.

Athabasca boring—*Cont.*

time had arrived when some experimental boring might with advantage be undertaken by the Government, and a vote of $7,000 was obtained from Parliament during the past session for the purpose of initiating this work, the arrangements for which were entrusted to the Geological Survey. After careful consideration, it was determined that a bore-hole should in the first instance be sunk at Athabsca Landing, at which place the depth of strata to be passed through in order to reach the horizon of the "tar sands" had, as above stated, been estimated by Mr. McConnell at approximately from 1,200 to 1,500 feet. On some grounds it might have been more advantageous to begin boring at a locality further to the north and east, where the depth of cover would be smaller and the actual known outcrop of the "tar sands" less distant, but the difficulties of transport for machinery and casing beyond the Landing militated against this. In another respect also Athabasca Landing appeared to be a suitable spot for a first test:—A wide low anticlinal by which the Cretaceous rocks of the plains are affected over a great area, tends towards the Saskatchewan near Egg Lake and if continued should reach the Athabasca near the Landing. The arch formed by these rocks is so low and diffuse that in consequence of the scarcity of natural sections it is difficult to trace it, but if continued to the Landing, experience elsewhere gained shows that the structure should be a favourable one for the concentration of any supplies of petroleum contained in the strata.

Selection of site.

Contract for boring.

After some inquiry and the receipt of tenders from thoroughly competent drillers, the lowest and most favourable of these was accepted and a contract for the work of boring was entered into with Mr. A. W. Fraser. Mr. Fraser has had much previous experience in boring for petroleum, both in Ontario and for the Indian Government in Burma and Baluchistan. So far as they have yet gone, the operations have been conducted rapidly and successfully by Mr. Fraser.

Total depth reached.

On October 24th, the bore-hole had reached a depth of 1,011 feet, when it was found necessary, owing to the incoherent character of the rocks, to stop work pending the arrival of more casing. This it is proposed to place in the hole during the winter, but the drilling itself can scarcely be resumed till the spring, as the great quantity of gas met with, renders it dangerous to keep a fire in the derrick-shed or anywhere in the vicinity of the well.

The following account of the work is summarized or extracted from Mr. Fraser's report, received on December 19th.

Mr. Fraser reports that the plant for the boring was shipped from Toronto on 14th July, 1894, by the Canadian Pacific Railway. It

arrived at Edmonton on the 26th of the month, when teams were at once procured and the machinery and tools were sent on to Athabasca Landing. Athabasca boring—*Cont.*

The Landing is one of the principal forwarding points of the Hudson's Bay Company, and the company has in consequence acquired there, a grant of a section of land. As this covers most of the flat near the river, Mr. Fraser found some difficulty in selecting a suitable spot for the boring operations, which he had been instructed should be upon government land. A good site was, however, finally chosen 550 feet west of the company's west line, 10 feet above low-water level in the river and some 250 to 300 feet lower than the surrounding country. This site was inspected and approved early in August by Dr. A. R. C. Selwyn. Details of the work.

Ground was broken on the 1st August, and on the 15th of the month, when all the machinery had arrived, the drilling was begun. An excavation was first made by hand to a depth of 14 feet, in which a strong wooden pipe, made of $1\frac{1}{4}$ inch plank and 10 inches in inside diameter, was inserted. To the depth of 14 feet, the material passed through was chiefly clay, but at 6 feet from the surface a seam of coarse gravel was met with. The wooden pipe was fixed in a very hard boulder-clay.

The further continuation of the boring is reported on in detail by Mr. Fraser, as follows :—

"The drilling proper was then begun through a gray shale. At 23 feet, a stratum of hard rock was encountered about 6 inches thick.

"At 37 feet, iron casing was put in, of a diameter of 7 inches, inside measurement.

"From this depth to 136 feet a gray shale continued. At 136 feet we encountered a hard stratum about one foot thick. The shale was falling so badly that it was impossible to obtain a sample of these cuttings.

"From 136 feet to 182 feet the shale was the same, very soft and caving in very badly. At the latter depth, another hard stratum, 1 foot thick, was met with.

"From 182 to 230 feet the same sort of shale continued, no hard streaks being encountered.

"At this depth (230 feet) the $5\frac{5}{8}$ (inside diameter) casing was put in, as the shale was falling in so quickly that no progress could be made without the casing.

"At 245 feet a hard streak, similar to the preceding ones, was struck, and on drilling into it a strong flow of gas was met with. This flow threw the water that was in the bore-hole over the top of the der- Gas met with

Athabasca boring—*Cont.*

rick. There was no oil with this flow of gas, but it made the drilling more difficult, as it cut down the shale and caused it to cave in badly. We therefore drilled another 15 feet and put the casing down at 260 feet.

"At 267 feet more gas was struck.

Large flow of gas.

"From this depth to 334 feet the drilling was through shale and it caved very badly. At 334 feet another large flow of gas was struck. The roaring of the gas could be heard half a mile away from the works, and it was considered unsafe to work with the boiler in its former position, so it was removed 55 feet. My foreman, who had seen the big gas well at Kingsville, Ont., assured me that the flow of gas was as strong as in that well.

"After striking this flow of gas, it was impossible to make any progress. We worked for days and could not get to the bottom of the bore-hole. Finally, by adopting the plan of letting the water for drilling down the hole in the sand pump, we managed to get the drilling started again.

"At 338 feet a hard streak was met with about one foot thick.

"From 388 feet to 400 feet the drilling was through very soft shale.

"From 400 feet the shale was slightly harder, and at 425 feet a hard stratum about one foot thick occurred. From 425 feet to 450 feet the formation was gray shale, with several streaks of hard rock from 6 inches to 2 feet thick.

"From 450 feet to 500 feet, the drilling was through the usual gray shale.

"From 500 feet to 550 feet, the shale was darker and very soft and caved badly.

"From 550 feet to 580 feet, streaks of sand rock varying from 1 to 2 feet thick were met with.

"From 580 feet to 600 feet, the formation was dark shale and very soft.

"At 625 feet, the $5\frac{5}{8}$ inch casing was put in. The formation was soft shale and not hard enough to support the casing which was hung on the clamps at the top.

"From 625 to 780 feet, no change was met with. It was soft black shale between these depths.

Flow of salt water.

"At 780 feet salt water was struck. The water was not in very great volume. A fragment of rock obtained from this depth, showed crystals of salt, but this specimen has been lost. A strong flow of gas was also obtained at this depth. After passing this water vein, the shale caved in so badly that it was deemed advisable to put in the $4\frac{5}{8}$

casing. This conclusion was come to after much time had been spent in pumping the mud. The casing was put in to a depth of 825 feet.

Athabasca boring—*Cont.*

"From 825 feet to 900 feet the shale was much harder and bluer in colour, but after passing 900 feet it again became soft and dark in colour. It continued so to 1,011 feet, the present depth of the well.

Suspension of work for the winter.

"At that depth further progress was found to be impossible without putting down the casing. This could only be done by getting an under-reamer, to work a shoulder off the bore-hole ahead of the casing, and without pulling the latter.

"It was thought advisable to obtain about 300 feet of the $5\frac{5}{8}$ inch casing in addition to the 625 feet already in the hole, and drive it down past the salt water vein at 780 feet. This would take so much pressure off the $4\frac{5}{8}$ inch casing.

"The $5\frac{5}{8}$ inch casing was then driven a few inches to ascertain whether it would be possible to drive it or not. As the season was so far advanced that the necessary tools for under-reaming and the 300 feet of $5\frac{5}{8}$ inch casing could not be gotten on the ground before the extreme cold weather set in, it was determined to close down operations for the season, with the exception of driving the $5\frac{5}{8}$ inch casing as far as it would go on its arrival on the ground.

"To prevent the $4\frac{5}{8}$ inch casing from becoming fixed in the bore-hole during the winter months, the 825 feet was drawn up and placed to one side for spring operations. The 625 feet of $5\frac{5}{8}$ inch casing remaining in the bore-hole amply protected it.

"Since that time, the sanction for the purchase of the 300 feet of $5\frac{5}{8}$ inch casing having been obtained, it was purchased and sent to Athabasca Landing, together with the necessary tools for carrying on the under-reaming ahead of the casing.

"After the inner casing had been pulled out, and there remained in the 625 feet of $5\frac{5}{8}$ inch, an iron cap was screwed into the latter, and from the evidence of the pressure of gas, it was estimated that there was at least 50 pounds pressure to the square inch.

Summary of bore-hole.

Summarizing the above, Mr. Fraser gives the present state of the boring as follows:—

Depth of bore	1,011 feet.
Cased with $7\frac{1}{2}$ inch casing	37 feet.
Cased with $5\frac{5}{8}$ inch casing	625 feet.

On the ground for use in the spring,

$4\frac{5}{8}$ inch casing	1,200 feet.
En route $5\frac{5}{8}$ inch casing	300 feet.
En route $4\frac{5}{8}$ inch casing	100 feet.

Athabasca boring—*Cont.*

Judging from the rocks so far passed through, as compared with Mr. McConnell's published section, obtained from natural exposures further down the Athabasca River, Mr. Fraser expresses his doubt as to whether the La Biche shales are unusually thick at the Landing or whether the Pelican sandstones may here be wanting and the La Biche and Pelican shales combined in a single series. Mr. Fraser inclines to the first mentioned theory and on this supposition adds,—

Remarks by Mr. Fraser.

"Owing to the greater thickness of the La Biche shales, the oil sands will probably not be met with at a less depth than 1,500 feet.

"With a view to the economic value of the discovery of petroleum in the far North-west, the present site must be regarded as a wise selection. Had the test been made lower down the river, and nearer to the outcrop of the "tar sands," the finding of petroleum might have been more certain, but if found, nothing could be done about it until tests were made at the Landing or elsewhere to discover whether it was not to be had nearer to the railway.

"Much interest has been taken in the development of this oil field by the residents of Edmonton and the surrounding country and they expect a material increase of prosperity should oil be found in quantities sufficient to make it a profitable enterprise. Already a few have profited by the money spent in prospecting and have earned small sums of money which have materially helped them in paying for lands.

"The Hudson's Bay Company has evinced great interest and its agents at Edmonton and Athabasca Landing, Mr. Livock and Mr. Wood, have used every endeavour to help on the work, and I am greatly indebted to them for their ever willing help."

Examination of drillings.

Specimens of the drillings obtained from different depths in the bore-hole have been subjected to a preliminary examination by Mr. McConnell, with the object of instituting a comparison between the beds passed through, and those described by him in the natural outcrops further down the river. In consequence, however, of the uniformity of the material met with in the boring, no results of a positive character were obtained, and at the present stage of the work it is not possible to decide the stratigraphical question above referred to by Mr. Fraser, nor to make any closer estimate of the probable depth to be penetrated than that already quoted from Mr. McConnell's report.

Expenditure.

The total expenditure on this boring to date has been $4,203.37, but the full amount due to the contractor for the depth now reached is not payable, according to contract, till the completion of the boring to the contract depth of 1,200 feet. Over $1,000 of the above expenditure has been incurred in the purchase of casing and its transport to Edmonton. If it is deemed advisable ultimately to withdraw this

casing from the present hole, most of it will probably be servicable for a second boring. This, and the fact that the boring plant is now all in the district, should render the cost of further experiments relatively much less than that of the first.

Athabasca boring—*Cont.*

Plan of further operations.

It appears to be most important that the investigation of the petroleum fields of Athabasca and Northern Alberta, thus begun during the past summer, should be continued until the main features at least of the character and value of these fields shall have been determined. The boring at Athabasca Landing has not yet attained the minimum depth at which the occurrence of petroleum at that place is considered probable; but should petroleum not be encountered in considerable quantity at a less depth, and should no unforeseen accident occur in connection with the work, I would advise that this boring be carried down to a depth of at least 1,500 feet. In any case the information obtained thus will be of great value in determining the position and useful depth for further sinkings. In the event of the discovery of petroleum at Athabasca Landing, the machinery should be moved to another carefully selected locality further to the south and nearer to railway communication. In the opposite event, the continuation of the investigation is no less necessary, for its abandonment at that stage would tend only to discourage further enterprise, while the probability of an ultimate success would in reality be not materially lessened. It would then, however, be advisable to select a place for a second boring further down the Athabasca River, nearer to the actual outcrop of the bitumen-bearing sands and where the depth of the overlying rocks is less, although the distance from existing means of communication is greater.

Importance of the experiment.

All indications favour a belief in the existence of a great petroleum bearing region in the North-west, and the results which would flow directly from the definition of such a region, are so important, as to warrant any expenditure which may be necessary in that direction. It is not probable that petroleum, if found in Northern Alberta or in Athabasca, would seriously compete in the east with the already established petroleum industry of Ontario; but the considerable and yearly increasing demands of British Columbia and the North-west Territories would afford a local market which might be large, as, if the oil could be furnished at a low price, it would undoubtedly be employed as a liquid fuel for railways in many parts of the country. The comparative proximity of the Athabasca region to the Pacific, further indicates that an enormous foreign demand, coextensive with the shores of that ocean, might be most profitably supplied from this region. The extent of this market may be in part realized when it is stated that

Athabasca boring—*Cont.*

the export of illuminating and paraffine oils from the United States to Japan, China and Hong Kong alone, amounted in 1893 to 67,572,136 gallons.

British Columbia.

British Columbia.

The principal part of the time spent by me in the field during the past summer was devoted to the completion and extension of geological work previously undertaken in British Columbia. It was, however, arranged that I should in the first place occupy a few days in the foothills of western Alberta, in examining some of the more recently discovered outcrops of coal and in further investigating the superficial deposits of that region; also that I should, if possible, pay a short visit to that part of the Cariboo district of British Columbia in which extensive hydraulic mining operations have lately been initiated.

On the 23rd of June I left Ottawa, accompanied by Mr. R. G. McConnell, and on arriving at Lethbridge, engaged a light wagon, three horses and a driver, with which equipment we spent about sixteen days in various parts of the foot-hill region between Macleod and Calgary, arriving at the last-named place on July 9th. From Calgary, Mr. McConnell went to the scene of his further operations in the West Kootanie district, while I proceeded to Kamloops, meeting my assistant, Mr. J. McEvoy, there.

General nature of work done.

Attention was then directed to the revision and further investigation of a number of localities comprised within the area of the Kamloops map-sheet, situated for the most part in the vicinity of Kamloops Lake and along the Thompson valley below the lake. The matters upon which further information was desired, were those which had occurred in connection with the compilation of the geological map and report last winter. As this map and the report are now ready for publication, it will be unnecessary to allude further in this summary to the results obtained, except in the case of certain localities visited where minerals of economic value have lately been found or worked, some notes on which may be of immediate interest. This part of the work was completed on August 4th, when, leaving Mr. McEvoy with two men and the horses, to continue the examination of the region east of Kamloops, I set out for the Cariboo district.

From the time of leaving Ashcroft station, on the railway, to the date of my return to that place on August 18th, thirteen days were occupied in the journey to and from the South Fork of Quesnel River and Horsefly River, including the time spent at these localities. Although but a few days were thus actually available for the investig-

ation of the hydraulic mines near these places, the observations made are of much interest. Some details respecting them are given below.

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After rejoining Mr. McEvoy, the remainder of the season was spent in continuing the exploration of the area of the Shuswap sheet, including a critical re-examination of some parts of the sections of the older rocks afforded by the Shuswap Lakes. During the time in which I was engaged in this work, Mr. McEvoy made an independent exploration on foot, across the mountains between the heads of Adams and Shuswap Lakes. As the Shuswap sheet is not yet ready for publication, a few of the more important points noticed will be mentioned here.

On October 2nd I left Kamloops for Ottawa, having been recalled there in consequence of Dr. Selwyn's departure for England on leave of absence.

Mr. McEvoy remained in the field till November 5th, when the broken character of the weather rendered it advisable to suspend operations. He reached Ottawa on November 14th.

Deposit of cinnabar.

Recent developments of economic minerals in the area of the Kamloops sheet.—What may prove to be an important deposit of cinnabar has lately been found in the vicinity of Copper Creek, Kamloops Lake, and several contiguous claims have been taken up on this, on the west side of the valley of the creek, near its mouth. The claims have, I believe, been combined in a single property, but the best looking deposit of ore occurs on the "Rosebush claim," where a shaft about fifty feet deep, connecting below with a drift more than fifty feet long, has been opened. The height of this place is about 450 feet above the lake. Other small openings have been made in the same vicinity, as well as a second shaft, thirty-five feet deep, on the "Yellow Jacket claim," about a quarter of a mile northward of the Rosebush.

The cinnabar occurs in irregular sparry veins, consisting chiefly of calcite and quartz, with some dolomite, traversing zones of a gray felspathic and dolomitic rock which readily weathers to a yellowish colour. Both these zones and the contained veins, as a rule, run nearly magnetic north-and-south through the main rock of the hills, which is a dark greenish-black, Tertiary eruptive, containing pyroxene and olivine, possibly a melaphyre, but much decomposed. A considerable quantity of rich ore has been taken from the wider portions of the main vein opened on the Rosebush. Although the slopes of the hills are abrupt, they are almost everywhere covered with drift deposits, and much more work is necessary in order that the true value of the deposit may be ascertained. Exploratory trenching in an east-and-west direction

British Columbia—*Cont.*

would be the most economical method in the first instance. A little antimony sulphide (stibnite) is observable in some parts of the ore.

Another claim, upon which very little work has been done, is the "Last Chance, No. 2," situated on the east side of Copper Creek, near the junction of the Tertiary volcanic rocks with a small area of decomposed granite. Small quantities of cinnabar are found here, and some narrow seams of molybdenite also occur. In the adjacent granitic mass, minute bright red specks of cinnabar may also be detected, and it would appear that the extensive decomposition of the basic volcanic rocks of this region, by heated waters or steam, has led to the diffusion of a certain quantity of cinnabar, through some parts of both classes of rocks, and to its concentration in some of the veins.

Decomposition of a similar character, has affected the rocks seen on the opposite side of Kamloops Lake, along the railway, to the east of the mouth of Cherry Bluff Creek. No cinnabar has been observed here, but distinct traces of cinnabar are found in seams cutting some of the rocks at Six-mile Point, also on the south shore, but further to the west.

These occurrences indicate that search may be made for cinnabar over a considerable area, with some prospect of success.

Copper ore.

Also on the east side of Copper Creek, but about half a mile back from the lake, a claim named "The Tenderfoot" has been taken up on an irregular deposit of copper ore (bornite). But little work has been done here, and there appears to be little reason to hope that the deposit will prove to be a really valuable one.

Native copper.

Copper Creek derives its name from the fact that the Indians have from time immemorial known it as a locality of native copper. Specimens were obtained last season from the serpentinous decomposed rocks to the east of the stream, which show some of this native copper, but the quantity is probably inconsiderable from an economic point of view.

China-stone.

Specimens having been received from Mr. G. De Wolf and others, of kaolin and china-stone from a locality on the west side of the Thompson opposite Spatsum station, this locality was visited during the summer. It was found to lie in the remarkably shattered decomposed zone of rocks which runs along this part of the Thompson River for many miles; but in this place, the rocks instead of being merely silicified and reddened, have suffered a more complete change.

They appear to have been in the first instance thoroughly decomposed and pyritized, and subsequently more or less completely leached by acid waters resulting from the decomposition of the pyrites. The materials so produced, when cut into by lateral ravines, form bare

crumbling banks of red, yellow and white colours, upon which scarcely any vegetation grows. Some parts of these are almost purely siliceous, while others consist of mixtures of quartz and kaolinite in varying proportions, with often a perceptible efflorescense of soluble salts with a styptic taste. The white and thoroughly leached rocks are those which have attracted attention as china-stone, and in them, kernels and veins of pure white gypsum occasionally occur. It is doubtful, however, whether any great quantity of china-stone could be easily quarried, free from iron stains, while the kaolinite could only be obtained pure and in quantity by crushing and washing the lighter coloured parts of the deposit.

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It is difficult now to say, what the original composition of the rocks here was. Their alteration is evidently in connection with the edge of the granitic mass to the eastward. The area occupied by these peculiarly altered rocks is probably about half a mile long by quarter of a mile wide.

Glen Iron Mine.

The Glen Iron Mine, situated on the western part of Cherry Bluff, Kamloops Lake, was re-visited during the past summer. This deposit was noted in my report for 1877 (p. 118 B) and is also farther described by Mr. J. McEvoy in his summary report for 1893. No work was in progress at the time of my visit in 1894, but operations have been since resumed. There is evidently a large quantity of excellent magnetic ore at this place.

Van Winkle Hydraulic Co.

An inspection was also made of the property of the Van Winkle Hydraulic Mining Company, on the west bank of the Fraser about two miles above Lytton, where a good hydraulic plant has been established and is being operated. I was so fortunate as to meet here Messrs. J. M. Buxton and H. E. Newton, both interested in this enterprise. The original Van Winkle Flat, well known in former years as rich placer ground, consisted of the lower river-terraces, from a height of about one hundred feet above the river, down nearly to the river level; while river-bars, bare only at low water, were also worked with profit. The work was confined to the upper layers of these terraces and flats, and is reported to have averaged at the rate of about $6 per day to the hand.

The object of the present owners is to work by the hydraulic method, the whole mass of the higher terraces or "benches" which rise from the river in successive steps toward the base of the mountains on the west. The first principal bench has a height of about 100 feet above the mean high-water of the Fraser, the next is about sixty feet higher, and there are others at still greater heights.

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The water employed is obtained from the south branch of Stein Creek, and being chiefly derived from the melting snow of the higher mountains, it cannot be depended upon after the weather becomes cold in the autumn. An ample and constant supply might, however, be obtained by extending the ditch to the main stream of Stein Creek. The water is delivered at the sand-box at a height of 377 feet above mean high-water of the Fraser, giving a head of more than 300 feet at the work. The pipe-line from the sand-box is about 1,500 feet long, with a diameter of eighteen inches, and about 1,600 miner's inches of water is employed. A large amount of gravel has already been excavated, the pit taking the form of an isosceles triangle, of which the apex touches the river, the base being at a distance of about 1,200 feet. The ground has not proved so rich as was anticipated, but the working face is now being carried back into the second bench, in which the gravels, wherever prospected, appear to be more highly auriferous.

Age of the auriferous drifts.

It is difficult to explain the geological relations of the gravels exposed in this work, without entering into the general question of the deposits of the Fraser valley in greater detail than is here possible. The history of these deposits is traced in the report on the Kamloops sheet, now ready for publication; but as this is the first attempt on a large scale to work the higher benches of the Fraser valley, the main facts may be alluded to.

All the gravels here exposed are believed to be later glacial or post-glacial in age. No boulder-clay is seen, nor is any true bed-rock reached. The lowest deposit cut through, consists of well rolled gravels, sometimes bouldery, with a sandy matrix, which pass largely, at a distance from the river-bank, into coarse irregularly stratified sand and fine gravels, occasionally lightly cemented. This deposit appears to represent what now remains of that filling of the valley due to a period subsequent to that of the removal of the boulder-clay by river erosion. It is comparatively poor in gold.

When the conditions permitting such accumulation changed, and the river again began to cut down through the deposits above mentioned, it flowed from time to time over different parts of the whole width of the valley, producing the existing series of terraces and benches in the course of its irregular excavation, and leaving portions of its bed at different heights, filled with more recent river gravels. These consist in part of the rearranged material of the lower deposit, in part of materials brought by the river from places up stream. In these old river gravels the greater part of the gold, found at this place, occurs. It is to be noted, that wherever the lateral streams in the immediate vicinity cut through gold-bearing rocks, the lower deposit

first described, may be expected to contain a considerable proportion of gold. This should be the case for instance in the vicinity of Lillooet. Of the old river-channels themselves, the higher must in all cases be the older, the lowest and latest being represented by the gravel deposits of the flats nearest to the present stream.

British Columbia—*Cont.*

In the Van Winkle pit, the stratified auriferous gravels forming the upper part of the lower, or 100-foot bench, are probably newer than those of the next bench above, which is now being worked into; but this cannot be actually determined till the lowest part of the channel filled by the last-named gravel is exposed, and its height compared with that of the 100-foot bench. The older auriferous gravels due to a still earlier period of river erosion, which may be assumed to exist on the bed-rock proper, or upon whatever may remain of the boulder-clay, must now be altogether beneath the level of the present river.

River dredging.

In the vicinity of Lytton, two companies are also at work experimenting with barges and sand pumps or equivalent apparatus, with the object of working the auriferous gravels of the present river-bed, but no details are available in respect to the result of these operations. Renewed interest is also being taken in the gravel deposits near Lillooet and elsewhere, and there is now every prospect that all such deposits along the Fraser River will be thoroughly examined and, where found satisfactory, worked.

Work done on Shuswap Sheet.

Notes on the Area of the Shuswap Sheet.—The work done on this area consisted chiefly in the tracing out of some of the geological boundary lines and in the re-examination of parts of the shores of the Shuswap Lakes, for the purpose of ascertaining the interrelation and limits of the older formations there, in the light of later investigations on Adams Lake and in the Selkirk Range. The excellent sections found along Adams Lake in 1890, showed, that overlying the Shuswap series (referred to the Archæan) there is a great thickness of rocks which have been provisionally classed as Cambrian, consisting below of black argillites and limestones, named the Nisconlith series, and above of green and gray schists named the Adams Lake series. The same rocks appear on the Shuswap Lakes, but their arrangement and the conditions of metamorphism in which they are found, render the problem there more intricate. The results obtained during the past season on the Shuswap Lakes, have not yet been laid down on the map, but in the main, it may be stated, that there is now no great difficulty in separating the several rock-series in accordance with the key furnished by Adams Lake. In a few places, however, the extreme degree of metamorphism which the rocks have suffered makes such separation

Old rocks Shuswap Lakes.

British Columbia—*Cont.*

more troublesome and less satisfactory. The rocks representing the Adams Lake series, under certain conditions assume an almost gneissic character, and whatever angular unconformity may have existed between the Cambrian and the Archæan has generally been obscured by the close flexure and compression to which both together have since been subjected.

The economic importance of the separation referred to is, however, not inconsiderable, because of the differences in character which may be traced in the ores met with in the two formations respectively, those of the Cambrian areas having, particularly in the Kootanie region, so far proved to contain most of the more valuable ores.

There is every reason to believe that the lowest Cambrian or Nisconlith series is really unconformable to the Shuswap series, and it is very probable that it has been originally deposited irregularly upon an already denuded surface of these older rocks. While the Nisconlith rocks are often chiefly composed of argillites, they appear in most places on the Shuswap Lakes to be represented by argillaceous limestones of dark colours and in flaggy layers, generally more or less micaceous.

Exploration, Adams Lake to Shuswap Lake.

The Shuswap Lakes appear to have been excavated in an area of the older rocks characterized by large and irregular infolds of the Cambrian strata, and one of the most notable features met with, is the great abundance of quartz veins in the vicinity of these lakes. This whole region is therefore one, inviting examination by the prospector, and likely, in some places at least, to repeat the conditions already found under similar circumstances in the West Kotanie district.

On the country traversed by him between Adams and Shuswap Lakes, Mr. McEvoy gives the following note :—

"Leaving Adams Lake on the 18th September, from the mouth of Mo-mich' River, which flows in on the east, side five miles from the head of the lake, we followed the north side of the river on foot. Two miles up, a small lake, a mile long, was reached. This lake is connected by a few rods of rapid water with another lake, two miles and a quarter in length. The valley of the river and the country about the lake is covered by timber of fair growth, Douglas fir, cedar and white pine.

"Salmon run up to this lake plentifully at this season, and ascend the stream at its head for some distance further. From the head of the lake, the Indian route followed lay in a north-east direction for a distance of three miles and a half, when we came to a river which is the main water supply of Mo-mich' River. The altitude of this point is practically that of the summit of the pass to Shuswap Lake, and is between 1,600 and 1,700 feet, only, above sea-level.

"From this place there was no track whatever, but after following up the north-west side of the river for some distance we crossed it and turned due east. The route was through a dense forest of fine timber consisting of white pine and cedar. At a distance of four miles, Tuk-em-ap-ten, a lake three miles long, is situated. There, some open and flat land was found, with very good soil, a considerable tract being a natural meadow. Leaving the head of Tuk-em-ap′-ten Lake, the summit of the pass was crossed and the head of Hum-am-ilt reached at a distance of three miles. White silts were noted on crossing this summit, and as viewed from either side, the summit presented a terrace-like aspect. Here we were delayed two days by wet, cloudy weather, during which it was impossible to get the necessary sketches from the adjacent hills, and during our wait we made a "dug-out" canoe with which to traverse the lake. Hum-am-ilt Lake proved to be seven miles and a half long, with four narrows, across one of which the beavers had made a dam during the summer. The stream flowing out of this lake falls into Shuswap Lake, three miles and a half below Seymour River, at the head of Seymour Arm.

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"The country between Hum-am-ilt Lake and Shuswap Lake supports a heavy growth of very fine timber, which will before long be of great value, if it can be preserved from destruction by fire.

"The rocks throughout the whole route are gray gneisses of the Shuswap series, with areas of granite in several places. The latter, owing to the scarcity of exposures, will be difficult to define.

At a later date, Mr. McEvoy visited a recent discovery o silver ore near Adams Lake, which he thus describes :—

Silver ores, Adams Lake.

"The 'Homestake' mine is situated on Pass or Squa-am Creek about two miles and a half in a straight line from the end of Squa-am Bay, Adams Lake. The location is on a small stream flowing into Pass Creek on the north side, at a height of 750 to 800 feet above the bottom of the valley. A good deal of ore has been taken out and shipped, from the first opening, which is on a somewhat irregular vein dipping in general N $<$ 70°, and branching to the west. The country-rock having since caved in, little could be seen of this vein at the time of my visit.

"About ten feet above the last, is a band of bedded rock highly impregnated with barite and galena carrying silver. Specimens of this ore can be distinguished from vein matter by its banded appearance. The mass varies in thickness from about ten feet at the stream, to twenty-five feet and more at a point about 200 feet to the west. The dip of the whole mass is N. $<$ 25°. A drift, now one hundred and twenty feet long, is being run in below to intersect this deposit. The country

British Columbia—*Cont.*

rock is a talcose schist, light gray in colour, and in the vicinity of the first-mentioned locality is an almost pure talc-schist, dipping to the north at an angle of 25 degrees."

Depth of lakes.

During the time spent on the Shuswap Lakes, and while Mr. McEvoy was travelling northward to the head of Adams Lake, the opportunity was taken to ascertain the depth of these lakes. This was found to be extremely uniform over considerable parts of their area, but with unexpected and as yet unexplained exceptions. Little Shuswap Lake has a nearly flat bottom, with a depth varying from about 58 feet to 74 feet measured in this as in other cases, from the mean high-water mark. The deepest water found in Great Shuswap Lake was 555 feet, about six miles northward from Cinnemousun Narrows, in the Seymour arm, but nearly the whole lake is notably deep. Adams Lake however, much exceeds either of the Shuswap Lakes, as it is for a length of some twenty miles, about 1,150 feet, the greatest depth being 1,190 feet. As the height of the surface of this lake is 1,380 feet above the sea-level, its present bed is therefore 190 feet only above the sea, although distant nearly 200 miles from the nearest part of the ocean.

Hydraulic mining in Cariboo.

Observations on Hydraulic Mining in the Cariboo District.—Although hydraulic mining has long been practised in the Cariboo region, it has hitherto been on a comparatively small scale and confined to the immediate vicinity of the older mining camps. The isolation of the district from main lines of communication has limited enterprise in this direction almost entirely to what could be done with local resources. During the past summer, however, work on a much larger scale has been actually begun in several places, with results, so far as it has gone, of a very gratifying character. Capital has been interested in this expansion of hydraulic mining sufficient to meet the heavy initial expenses of long ditches and pipe-lines with the most approved modern appliances. These operations have already drawn general attention to the extensive gravel deposits of the Cariboo region, which, although less rich than the old channels originally worked by drifting, are enormously greater in area. The country as a whole is one well supplied with lakes and streams at every different level, and thus well suited for the hydraulic working of any of the gravels which may prove to be of a payable character.

It is but just to add, that the present renewed interest in the Cariboo district is very largely due to the practical knowledge and advice of Mr. J. B. Hobson, who is in charge of the works of the Cariboo Hydraulic Mining Company and of those of the Horsefly Hydraulic Mining Company, both of which it is anticipated will be in full opera-

tion early next spring. It is certain that extensive prospecting work will be carried on next summer in various parts of the district, and it is therefore advisable to give here, some of the more important facts already determined which may be of service to the prospector. During my short visit to the district, attention was chiefly given to the developments made by the two companies above named, and some notes on these will first be given. The places referred to will be found laid down on Mr. Bowman's map of the Cariboo mining region, published with the Annual Report of the Geological Survey (new series) vol. III. British Columbia—*Cont.*

Cariboo Hydraulic Mining Co.

The property of the Cariboo Hydraulic Mining Company, is situated on the south side of the South Fork of Quesnel River, about three miles above the village of Quesnel Forks. It comprises several claims and is believed to cover about 8,500 feet of an old high channel of the river, separated from the modern deep and cañon-like river gorge, for a considerable part of its length, by an exposed rocky ridge known as French Bar Bluff. Near the lower end of the property, on Dancing Bill Gulch, successful hydraulic mining, on a small scale and with imperfect appliances, has been carried on for a number of years by a Chinese Company. At a distance of about 3,000 feet further east, on Black Jack Gulch, a good deal of work had been done by the South Fork Company, but without effectively reaching the richer gravels, which are below the level of the rim-rock where this has been cut through. Short ditches had been made by both these earlier companies, and the exposures in their hydraulic pits afford most of the information obtainable as to the character of the deposits. A ditch with a total length of seventeen miles, and a capacity of 3,000 miner's inches, has now been laid out by the present company and will be completed in the spring. This is to derive most of its water from Polley's Lakes, situated in the hills to the south-eastward. It is also, I believe, ultimately proposed to bring an equal volume of water from Moorhead Lake, by means of a second ditch which will be thirteen miles in length.

Lower pit.

At the lower or "China pit" the bed-rock of the old channel where cut by the present river-bank is believed to be approximately 134 feet above the river. The head of the train of sluices near the working face is 200 feet above the same datum, while the sand-box at the top of the bank is at a height of 489 feet; giving a head of water equal to about 289 feet, with ample fall for the dump, which is made direct into the river. Two monitors of five and five and a half inches diameter of nozzle respectively, are established in this pit. Mr. Hobson estimates that the old Chinese company removed in all, about 150,000 cubic yards of the bank, from which, it has been ascertained, $135,000

British Columbia—*Cont.*

of gold was obtained, without the employment of mercury, being at the rate of about 90 cents per cubic yard. The scanty water supply available in advance of the completion of the main ditch, enabled a run of only forty-seven hours to be made in the early summer. The mean volume of water employed was 2,000 inches and the yield was 302 ounces.

Upper pit.

The floor of the pit of the old South Fork Company is about 200 feet above the present river, and bed-rock has been found in test pits at a depth of about 30 feet below this floor, while above it, on one side of the gully, is a nearly vertical face of clay and gravels about 200 feet in height. The head of water from the sand-box to the present bottom of the pit is about 246 feet; but as already stated the rim-rock has not yet been cut through to the full depth of the old channel. It is proposed to begin active work here in the spring.

Geological conditions.

The geological conditions as displayed in the two pits above described are of great interest, but in the present summary it is possible only to allude briefly to the main facts.—In the old South Fork pit, the section, in descending order, shows—(1) Ordinary boulder-clay with many glacially striated stones, 60 feet; containing little or no gold. (2) Stratified sands and gravels 120 to 130 feet; yielding gold to the amount of about five cents to the cubic yard. (3) Hard "lower boulder-clay" with very few glacially striated stones, 30 feet; not known to certain any gold. (4) Well rounded gravels, to bed-rock, 30 feet; rich in gold, some prospects obtained from trial pits being as high as $20 to the cubic yard.

In the "China pit" the section exposed is as follows: (1) Stratified gravels, seen along a portion of the top of the face only, greatest thickness about 30 feet. These contain gold to the amount of about five cents to the cubic yard. (2) Boulder-clay about 100 feet thick, in what appears to represent the axis of the old channel, but running out to nothing on each side; not known to hold any gold. (3) Rather hard roughly stratified gravels and sands, with clayey mater; the stones well rounded and often large. Maximum thickness about 310 feet to bed-rock, minimum thickness (where the overlying boulder-clay is deepest) about 200 feet; rich in gold.

The gold content of the several deposits, as above stated, results from tests made by Mr. Hobson and communicated by him to me. The equivalency of the strata in the two pits is not quite certainly determined, but No. 1 in the "China pit" is believed to represent No. 2 in the "South Fork pit," No. 2 to represent No. 3, and No. 3 to represent No. 4 respectively. The bed-rock appears to be generally a much altered and shattered greenstone (diabase ?) penetrated by syenitic dykes and including a considerable body of syenite near the "China pit." In

regard to age, it would appear that the lower and richer deposit in each pit is pre-glacial, while the upper gravels in the "South Fork pit" (No. 2) are, certainly, and those in the "China pit" (No. 1) probably, of inter-glacial origin. British Columbia—*Cont.*

Horsefly Hydraulic Mining Co.

The Horsefly River, empties into Quesnel Lake at a distance of twelve miles from the outlet of the lake. Its sources are in a mountainous country to the eastward, but its lower part, here particularly referred to, flows northward. A good deal of prospecting and some remunerative mining has been done at different times along this river and its tributaries, and the Harper claims have for many years attracted more or less attention as extremely promising, but owing to various difficulties have not been extensively worked. The Horsefly Hydraulic Company's claims, are situated on the river at a distance of about six miles south of Quesnel Lake, and here very important operations have now been initiated. The river was notably rich in this particular part of its length and the bars had all been worked over by Chinamen some years ago. Mr. McCallum, the discoverer of these claims, rightly believed that the modern placers must have some local source of the nature of an old channel. In search of this he endeavoured, by ground-sluicing, to work back in the bank of the river, but finding the ground too heavy for his water supply, eventually drifted into the bank and succeeded in striking the old auriferous gravels. These were at first worked by drifting and afterwards with a small hydraulic plant, supplied from Rat Lake, which is now used as a reservoir by the new company. The mining rights of the discoverer were secured by purchase by the Horsefly Hydraulic Company, and in the course of the prospecting carried out for this company by Mr. Hobson, much has since been learnt in regard to the character and extent of the deposit.

Working plant.

By the system now successfully completed, water is brought from Mussel Creek, a southern feeder of the Horsefly, by a ditch and pipe-line aggregating over eleven miles and a half in length. The ditch is about ten miles long, with a capacity of 20,000 miners' inches. The pipe-line is steel, 30 inches in diameter, in two lengths aggregating 8,300 feet. There is also about 600 feet of flume. From the sand-box the water is led to the pit by two lines of 22-inch pipe, each of which is intended eventually to supply two monitors. Water is delivered from the main ditch with a head of 168 feet, and from the pooling reservoir with a head of 106 feet. The bed-rock constituting the floor of the pit is about 90 feet above the level of the river, and the working face (60 feet in height at its highest part) at the time of my visit was about 560 feet back from the river-bank. The dump is formed in the river itself, which is a moderately rapid stream, capable (particularly in high water) of removing a larger quantity of debris.

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Respecting the actual average gold content of the gravels, much has doubtless been ascertained since my visit, some $13,000 being reported as the result of the last "clean-up". The preliminary run made by the company, was estimated to have dealt with 21,333 cubic yards of gravel. It produced gold to the value of $5,000, or at the rate of about 25 cents per cubic yard, but about a third of the area then worked had already been drifted on bed-rock by Mr. McCallum, rendering it probable, in Mr. Hobson's opinion, that the unworked ground would average about 40 cents. A small quantity of platinum occurs with the gold at this place.

Yield of gold.

Geological conditions.

The bed-rock in the hydraulic pit consists of pale, Tertiary (Miocene or Oligocene) shales, clays, sandstones and conglomerates, only moderately indurated and, in general, easily removed by the jet whenever this is required. These rocks contain a few fossil plants and insects, and are inclined in various directions, but their upper surface is a nearly horizontal denudation plane. The working face shows, resting upon them, a thickness of from 30 to 50 feet of gravels, roughly stratified, and varying in character in different layers from almost bouldery material to sand. A few feet near the bottom is irregularly cemented, and some parts of this "cement" is so hard that it cannot be disintegrated by the water. The cementing material is chiefly calcite, but strontianite is found in crusts of half an inch or more in some of the interstices. Stems and fragments of wood are occasionally seen in the lower layers, in a condition approaching that of lignite. The general colour of the auriferous gravels is yellowish, but becomes bluish toward the base. They are directly overlain by a regular layer, of from ten to fifteen feet in thickness, of ordinary boulder-clay, which, except where covered by later gravels, forms the general surface of the country in the vicinity. In another part of the pit, a local deposit of rather fine, gray gravel is found between the boulder-clay and the auriferous gravel, but unconformable to both. This yields a small prospect of fine gold, but the boulder-clay itself is not yet known to hold any gold.

Pliocene gravels.

The auriferous gravels at this place are therefore distinctly preglacial in age, and may, with little doubt, be assigned to the Pliocene period of the Tertiary. While it is probable that they represent an old river-channel, this has not yet been clearly demonstrated, nor is it at all certain that they have any intimate connection with the present course of the Horsefly. The problem is one not only of great interest, but also of great importance in connection with the future developement of the field.

British Columbia—*Cont.*

Harper claims.

The upper end of the Harper claims, where some work has been done, is situated about four miles further up the river than the last. Small sections, made in the course of work near the river bank, here show yellowish auriferous gravels, precisely like those of the Horsefly claims and capped in the same way by boulder-clay. Several small shafts have been sunk in this vicinity and part of the river bank and bed has been worked by drifting and wing-damming. The Miocene bed-rock is found nearest the surface at six feet below the river-level. Though not thick, the auriferous gravels in this neighbourhood have proved to be exceptionally rich, and they appear to be somewhat widespread. Some miners were engaged at the time of my visit, in putting in water-wheels to drain small open-cast workings on the east side of the river; but for the working of the deposit here on a large scale, the hydraulic elevator would probably be the most appropriate appliance.

Thompson claim.

Adjoining the Horsefly claims on the north, is the Thompson claim, where the owner has been engaged for some years in drifting into the bank, with the purpose of reaching the supposed continuation of the depression or old channel in which the auriferous gravels of the Horsefly claims occur. The drift is now about 1,200 feet long. It cuts through Miocene rocks like those already described, somewhat flexed, and including a considerable bed of conglomerate, which I was informed, contains a little fine gold. There is no surface indication to show where an old channel may be expected to pass, and it would appear to be advisable here, to test the ground by boring in advance of the drift, before this is pushed further in the present direction.

The notes above given refer only to localities actually visited by me last summer. I hope to give, at a later date, a fuller account of the various deposits seen, which it is impossible to explain in detail without diagrams and sections. Exploratory work is being conducted at present in a considerable number of places throughout the Cariboo district thought to be suitable for hydraulic mining. Further attempts, with better appliances than before, are also being made to "bottom" some parts of the continuation of the well known auriferous channels of the central and mountainous portion of the district.

Willow River valley.

Mr. C. F. Law has kindly supplied some details of the work being done on the deep ground in the Willow River valley, in which he is interested. This is the main continuation of the valley of the famous Williams Creek. Near the mouths of Mosquito Creek and Red Gulch, four prospect holes have been bored to bed-rock through the alluvial materials filling the Willow River valley. The bed-rock was reached at a depth of from 67 to 109 feet. The old channel was discovered at the depth last mentioned, at a distance of about 500 feet to the south-

British Columbia—*Cont.*

ward of the present river, and was found to be capped by a hard ferruginous cement, beneath which is four feet of pay gravel, which from the samples brought to the surface appears to be very rich. Some good payable gravels were also encountered in the side ground, and a shaft, with adequate pumping and other machinery, is now being sunk on the deposit.

Work of a similar character to the above is also I understand being carried on by the Slough Creek Mining Company, in the valley so named, in which the old channel upon bed-rock is reported to have been reached by boring at a depth of 245 feet.

Gravel deposits at Quesnel.

In an article in *The Province* (Victoria, B.C., Nov. 10, 1894) Mr. Law directs special attention to a gravel deposit on the west side of the Fraser, opposite the mouth of the Quesnel River, which he proposes further to investigate. The deposit is capped by basalt, and Mr. Law very properly draws attention to the probability of its extension, and the existence of others like it in the great basaltic area to the west of the Fraser, * quoting Mr. Hobson's opinion to the effect that the Quesnel River system at a former period (before the excavation of the Fraser Valley) flowed westward to the coast. The gravel deposit here particularly referred to, was first noted by Dr. Selwyn in 1875, and a section showing its relations, based on measurements by Mr. Webster, is given in my report for 1875-76, (pp. 257, 263) according to which the base of the basalt capping is about 700 feet above the Fraser or approximately 2,380 feet above sea-level. Mr. Law has already ascertained that these gravels contain at least some gold, and from the appearance of the exposures he believes them to represent an old river-channel. Should this prove to be the case, it does not, however, follow that the old river flowed westward, it is perhaps even more probable that the general direction of the drainage in this region, was northward, during a considerable portion of the Tertiary period, as I have elsewhere suggested. Attention may further be directed, in this connection, to the notes given in my report already referred to (pp. 263-264) on very similar gravels met with on the lower part of the Blackwater River and elsewhere along the Fraser Valley. Some of these closely resemble the more lately discovered auriferous gravels of the Horsefly, and may be of the same age, although it would not necessarily follow from this, that all are equally auriferous, this being likely to depend on the local source of the gravels in each case.

General conditions of gold occurrence.

Many of the general questions relating to the conditions governing the occurrence of auriferous placer deposits in the Cariboo district as

* See Geological Map of a portion of British Columbia between the Fraser River and the Coast Range. Report of Progress, Geological Survey, 1875-76.

a whole, so far as these are already known, require treatment in greater detail than can here be accorded. It must suffice at the moment, to point out that the late developments have already resulted in greatly extending the area of prospecting and prospective mining, in the manner previously suggested by me on more than one occasion.* The central portion of the Cariboo district,—that in which the highly concentrated auriferous deposits of Williams, Lightning and other well known creeks have been worked—may be described as a mountainous region, surrounded by lower hills and lowlands to the south, west and north. In this mountainous tract, the valleys of streams are deeply cut, and the modern streams still occupy the lines of a very ancient erosion. In surrounding regions, the lower portions of the same streams have evidently, at different periods, flowed in many different courses, both before and after the date of the great basalt eruptions; being there subject to changes induced by comparatively slight alterations in relative level of different parts of the country, as well as to many other causes. Where the older channels thus formed, or the gravelly deposits discharged by them on wider areas, antedate the basalt flows, it is now as a rule difficult to find any superficial indications of their existence; but in the case of later streams, and in places to which the basalts have not extended, many of the old valleys may still be found and followed without difficulty. The superficial filling of such valleys, together with the latest changes in the courses of streams, have resulted chiefly from the deposits and effects of the ice of the glacial period, and the study of all the conditions and events of that period has, in British Columbia, a most direct connection and importance in relation to the questions of mining. Allusion has been made to some of these effects in previous reports, but much yet remains to be ascertained and applied, for the problem is essentially a new one in regard to placer mining, no such conditions of a general kind being met with in California, Australia or any other country in which alluvial gold mining has been extensively prosecuted.

British Columbia—*Cont.*

Importance of glacial phenomena.

In the pages which follow, some account is given by Mr. McConnell of recent discoveries and work in the West Kootanie district. A much more general interest is being awakened in mining throughout the province, and it may safely be affirmed that British Columbia has now fairly entered on a period of rapid and thorough development of its mineral resources.

Cost of field work $1,833.93.

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* Mineral Wealth of British Columbia. Annual Report of the Geological Survey. Vol. III., (N.S.) p. 45R *et seq.*

British Columbia—*Cont.*

Mr. R. G. McConnell was engaged during the earlier months of the year, in working up the results of his exploration of the previous summer in the Finlay River and Omenica country, of northern British Columbia. Many of the specimens brought back were carefully examined, a report on the expedition was in part written and a map prepared, the last-named branch of the work being conducted by Mr. H. Y. Russell. Mr. McConnell left Ottawa for the field on June 19th, and after a couple of weeks occupied in the foot-hills of western Alberta, as noted on a previous page, spent the remainder of the summer in the southern part of the West Kootanie district. The work thus begun here, it is intended eventually to publish as one of the regular sheets of the geological map of British Columbia ; the map-sheet as laid out, including Kootanie, Lower Arrow and Slocan Lakes, with the country in their vicinity.

On his field work, Mr. McConnell makes the following report :—

West Kootanie, work by Mr. McConnell.

" Nelson, which was selected for headquarters, was reached on July 26th, and on the 28th work was commenced at Ainsworth and carried on in different parts of the district until Oct. 15th. The principal regions examined were Ainsworth, Toad Mountain, Ymir Mountain and vicinity, the mountains south of Balfour, part of the Slocan region, Crawford Bay and Trail Creek. During the season I was zealously assisted by Mr. H. Y. Russell, who took charge of the topographical work.

" An endeavour was made to obtain a general knowledge of the geology of the different portions of the district, and to make as complete a collection as possible of the representative rocks and minerals for purpose of study during the winter, rather than to attempt at once to work out any part of the field in detail.

The rock series.

" The stratified rocks of the district may be roughly divided into three main groups. The oldest of these, the Shuswap series of Dr. Dawson, is probably of Archæan age, and consists of gneisses, mica-schists, bedded diorites and crystalline limestones. Resting on it is a great series of alternating bands of green schists and dark argillites, several thousands of feet in thickness, the age of which has not been determined. The latter is overlaid, apparently conformably, by a great volume of dark slates which are often calcareous and occasionally pass into impure limestones.

" The Shuswap series occupies the basin of the Kootanie Lake, from Kaslo south, for at least forty miles. It borders both shores of the lake, in bands varying in width from one to two miles or more. The strike, north of Balfour, is nearly north-and-south, but south of the

West Arm of Kootanie Lake it trends more to the west. The dip is almost invariably to the west, except where overturns have taken place. British Columbia—*Cont.*

Green schists.

"The series of green schists, dark argillites and limestones which overlies the Shuswap rocks, are well exposed along the wagon road from Kaslo to Three Forks. A section was measured at this point, but has not yet been worked up. The green schists and associated rocks extend southward with a gradually diminishing width to a point on the West Arm of Kootanie Lake, two miles west of Balfour, where they are nearly, or altogether cut off by the granites. Southward from this point, about four miles east of the Ymir Mountains, two bands of argillites interbedded with crystalline limestones occur, which probably belong to the same formation. The band of green schists which begins near Ward's Ferry, on the Kootanie, and strikes eastward across Toad Mountain to the head of the Salmon, then down the valley of this stream, are probably of the same age. The distribution of the latter band assumes the form of a bay of stratified rocks opening to the south, and penetrating towards the north the central granitic area of the district. The Toad Mountain schists are underlain on the east by the gneiss of the Shuswap series, and overlain on the west near Red Mountain by reddish-weathering slates.

Dark slates and limestones.

"The upper series of stratified rocks, consisting mostly of dark evenly bedded slates with some limestones, is largely developed in the Slocan country, and is well shown along the Kaslo wagon road from Fifteen-mile house westward to a point a couple of miles west of Three Forks, where this series is cut off by an area of eruptive rocks. Southward, the slates of this series strike into the great granitic mass which occupies the central part of the district, and are all cut off, with the exception of a narrow strip which skirts the granite on the west as far south as the West Arm of Kootanie Lake.

"Dark slates, somewhat similar in general appearance to those in the Slocan country, were observed on the Pend-d'Oreille River near the International Boundary and also on Sheep Creek, but it is impossible to say as yet if they belong to the same period.

"East of Kootanie Lake, the stratified rocks are subject to a different arrangement. At Gray Creek, the only place where they were examined in detail, the Shuswap series of schists and limestones are succeeded by several thousands of feet of quartzites and conglomerates, a group, so far as I know, entirely unrepresented west of the lake. Above the quartzites, light and dark green schists, interbedded with quartzites and conglomerates, occur, and are exposed along the valley for four miles, when they are succeeded by a band of quartzites about 2,000 feet thick, above which is a series of green schists.

British Columbia—*Cont.*

The latter is overlain by a band of coarse dolomitic conglomerate passing upwards into a dolomite. The dolomites occur near the summit of the pass, and are followed by green schists similar to those lower down in the series. It is probable that the latter are repeated by faulting, but owing to the summit being covered with snow at the time of my visit, I was unable to prove this.

Eruptive rocks.

"The eruptive rocks of the district occupy wide areas and belong to several periods. The oldest, as far as ascertained, consist of a series of basic dykes cutting the Shuswap group, but now in many instances so altered and foliated by pressure and other causes that they have the appearance of constituent beds. They occupy in some localities a considerable proportion of the area assigned to the Shuswap series. They are older than the overlying formations.

"Eruptive granitic rocks, much younger than those referred to above, occupy the western part of the region, from about the north end of Lower Arrow Lake south to Trail Creek and east to within a few miles of Kootanie Lake. They cover a continuous area of fully 2,000 square miles. Numerous bosses and dykes of granite and pegmatite also occur further to the east, along the borders of Kootanie Lake. The granites, where examined, are usually grayish in colour, are coarse grained, as a rule, and are often porphyritic. The principal constituents are feldspar, quartz, biotite and hornblende. The granites cut all the formations from the Shuswap series up to the Slocan slates, and are consequently younger than any of the stratified rocks of the district. A series of eruptive rocks still younger than the granites, is represented by diorites, and diabase and uralite porphyrites. These rocks occupy a considerable area in the Trail Creek country, and are important, as they hold the principal lodes of the district. It is possible that some of the porphyritic rocks, so abundant in the Toad Mountain region, may belong to the same group.

"In addition to the main areas of eruptive rocks, numerous dykes, some of them connected with the main areas, others much younger, as they cut through everything, are met with in every part of the district.

Visits to mines.

"A hurried visit was paid during the summer to the most important mining camps of the West Kootanie district, but as these must all be examined in detail in the future, it will only be necessary here to give a brief statement of the principal characteristics of some of the most important mines visited.

"In the Slocan country, my examination was limited to a few of the mines in the vicinity of the South Fork of Carpenter Creek.

Slocan.

"The 'Slocan Star' one of the principal mines examined, is situated on Sandon Creek, about a mile above its mouth. It was discovered

in August, 1891, by John Sandon and Bruce White, and has been worked continuously for the last eighteen months. Nine hundred tons of ore, principally galena had been taken out, and awaited shipment. This ore it was expected would average 100 ounces in silver and $2 to $3, in gold per ton, besides the lead, which was estimated at 76 per cent. British Columbia—*Cont.*

"The great fissure on which the 'Slocan Star' is situated, runs in a nearly east-and-west direction, almost at right angles to the strike of the country-rocks, and can be traced through several claims. It dips to the north at an angle of from 45° to 60°. It is irregular in character, widening out to sixty feet or more in places and in others dwindling down to less than six. Numerous short tributary cracks penetrate the country-rocks on both sides, and fragments of the latter have fallen into the rift in great numbers. The gangue is principally quartz and spathic iron. The country-rocks consist of hard, evenly bedded, dark slates, often calcareous and occasionally passing into quartzites. They are considerably disturbed for some distance on both sides of the fissure. "Slocan Star."

"The workings on the 'Slocan Star' consist of four tunnels. The upper two are short, but the third or main tunnel has been driven in as a cross-cut for 140 feet, and then follows the vein for over 500 feet. Ore occurs all along, but the main ore-body was struck at a distance of 130 feet from the end of the cross-cut and is of extraordinary proportions for such high-grade ore. It has a length of 150 feet and a width ranging from a few inches up to six feet or more, of ore entirely pure, with the exception of occasional thin partings of quartz and siderite. The solid galena is besides bordered on both sides by a considerable thickness of concentrating ore. Beyond the main ore-body, smaller ones were met with, and at the present end of the tunnel, the vein is four feet wide. The galena occurs both in a fine grained and a coarse cubical condition and in places has a foliated appearance probably due to pressure.

"A fourth tunnel 300 feet below No. 3, had been driven in 300 feet, but at the time of my visit had not reached the ledge.

"For many of the above particulars in regard to the 'Slocan Star' am indebted to Mr. Bruce White.

"East of the South Fork of Carpenter Creek, the high ridge separating the latter from Kaslo Creek is literally ribbed with valuable lodes. Along the southern slope of the ridge, seven nearly parallel leads, some of them traceable through several claims, occur within a distance of less than a mile. Of this group only the 'Ruecau' and 'Bluebird' were examined in any detail.

British Columbia—*Cont.*

"Ruecau."

"The 'Ruecau' runs in a direction N. 29° E. and dips to the east at an angle of 70°. The lead on which this mine is situated can be traced, for a distance of 4,500 feet, according to Mr. Harris, the manager, whom I have to thank for much information. The fissure varies in width from four to twenty feet, and is broken through hard, dark slates, which it cuts almost at right angles. The slates are traversed by numerous porphyritic dykes, all of which are older than the fissure, as they are cut by it.

"A tunnel following the lode has been driven in at the 'Ruecau' for a distance of 355 feet. The first sixty feet proved to be nearly barren, then ore was struck, and has since been followed pretty constantly for a distance of over 250 feet. The ore occurs on the hanging wall, and varies in thickness from a few inches up to several feet. Small disconnected ore-bodies are also met with on the foot wall. The ore is principally galena, largely altered into oxides and carbonates, the proportion being about one of the former to three of the latter.

"Eighty tons of galena, which it is stated yielded 176 oz. of silver to the ton and 76 per cent lead, were shipped from this mine during the winter 1893-94, and 500 tons of oxides and carbonates await shipment.

"The 'Bluebird' (Mr. Taylor manager) is situated about half a mile east of the 'Ruecau.' The lead has a width of from one to five feet and extends in a direction N. 70° E., with a series of little northerly jogs. The vein-filling consists of quartz, calc-spar and masses of the shaly country rocks.

"Bluebird."

"The 'Bluebird' has been worked in an intermittent manner for the past three years, and 340 tons of ore, stated to average 132 oz. silver and 72 per cent lead, have been taken out. The ore is galena, partially altered by atmospheric agencies into oxides and carbonates. It occurs in a series of disconnected and often overlapping ore-bodies, ranging from a few inches up to a foot or more in thickness. Ore-bodies of considerable size also occur interbedded with the slates adjoining the fissure. The 'horses' and country-rock of this mine, in common with that of most of the mines in the district, are impregnated to some extent with mineral, assays showing 5 oz. silver per ton and 6 per cent lead.

Other mines.

"Besides the two mines referred to above, work was being actively prosecuted at the time of my visit at the 'Deadman,' from which some very rich ore has been taken, and also at the important 'Noble Five' group; while on the northern slope of the ridge the 'Dardanelles' and 'Antelope' were in active operation.

"Some of the best mines in the Slocan district are situated on the long ridge separating the South Fork of Carpenter Creek from Slocan

Lake, but I was obliged, owing to lack of time to defer the examination of these to another season.

British Columbia—*Cont.*

"Most of the claims in the Ainsworth district were examined and reported on by Dr. Dawson in 1889, and with the exception of a short visit to the 'Highland' mine, my time, while in this camp, was occupied in geological work.

Ainsworth.

"The 'Highland' mine is situated north of Cedar Creek, about half a mile west of, and 1,100 feet above Kootanie Lake. The country rock here is a well foliated mica-gneiss, striking nearly north-and-south. The fissure on which the mine is situated has a width of from 10 to 20 feet, and cuts the gneisses in a north-easterly direction. The vein-filling consists of layers of soft whitish clay (probably kaolin), and quartz, together with masses of the country rock. The vein has been uncovered for a couple of hundred feet and several ore-bodies, principally galena, exposed, the largest of which has a thickness of from 6 to 7 feet. The workings include one open-cut and two tunnels, the lower of which has been driven in about 200 feet. The ore is stated to average 55 oz. of silver per ton and from 60 to 80 per cent lead.

"In the Toad Mountain country, work is being prosecuted at the 'Silver King' and 'Poorman' mines, both of which have been described by Dr. Dawson in the report previously referred to; but with these exceptions few of the mines in this locality are being worked extensively. Considerable prospecting has, however, been done during the past season and several promising gold and silver properties have been reported.

Toad Mountain country.

"A short visit was made to the 'Fern' mine, situated south of Hall Creek. This property consists of a quartz lead, traversing the green schists of the region. The lead has been opened up at several places and is fairly regular, with a width of from 5 to 6 feet. The quartz holds auriferous iron- and copper-pyrites besides some free gold, and is reported to assay, from traces, up to $70 per ton in gold.

"The Trail Creek mining camp is situated about seven miles west of the Columbia River, and six miles north of the International Boundary. The principal ore here is an intimate mixture of pyrrhotite and chalcopyrite, very similar to the Sudbury ore. It occurs in an area of eruptive rocks, consisting mostly of diorite and uralite porphyrite. The ore is mined chiefly for gold. The eruptive area is traversed by four or five main leads, each of which can be traced through several 1,500-foot claims, and on one, ten claims are stated to be located. The leads are nearly parallel, have an approximately east-and-west direction, and dip to the north at angles of from 60° to 70°. The

Trail Creek.

British Columbia—*Cont.*

main productive belt has a width of less than a mile, but some good claims occur beyond this limit.

"The ore occurs along the leads in ore-bodies ranging in size from small stringers a few inches wide, up to great lodes 10 to 15 feet in thickness and from 100 to 150 feet or more in length. The richness of the ore is also very variable, assays showing it to run from traces up to several ounces of gold to the ton.

"Leroy."

"One of the most important mines in the district, and that in which the most work has been done, is the 'Leroy.' This mine was located in 1890 by E. F. Topping, but is now being worked by a stock company with Colonel Peyton as managing director and E. W. Liljegram as local manager. It is situated on a spur of Red Mountain, about half a mile west of, and 350 feet above the town of Rossland. The mine is worked by means of a shaft following the ore-body. At the time of my visit, the shaft was down 300 feet and ore ranging in thickness from 1 to 10 feet had been followed all the way. At the bottom of the shaft the ore is 4 feet thick. A surface opening 40 feet west of the shaft, shows 6 to 7 feet of clean ore and the ore-body can be traced 100 feet or more east of the shaft. A second ore-body, several feet in width, occurs south of the shaft, and a third, stated to be 12 feet in width, but which was covered up at the time of my visit, lies to the north. The ore is a nearly pure mixture of pyrrhotite and copper-pyrites, flecked occasionally with small quartz blebs. The foot wall is well defined in places and is separated from the ore by a thin calcite layer. No distinct hanging wall was observed. 2,000 tons of ore, stated to average nearly $40 in gold per ton and from 3 to 5 ounces in silver, have been shipped from the 'Leroy.'

"The rocks in the vicinity of the 'Leroy' are fissured for a width of from 60 to 70 feet, but it is possible that these may be shrinkage cracks and that the ore here, like similar occurrences in Sudbury and other places, may simply represent the first basic segregations from a solidifying magma. More detailed investigations will however be necessary before this can be proved.

"War Eagle."

"A couple of hundred yards north of the 'Leroy,' is situated the important 'War Eagle' claim. This claim was located in 1890 by J. Bourgeois and J. Moriss and is now bonded to Clark, Finch & Campbell. Development work has not proceeded so far on the 'War Eagle' as on the 'Leroy,' but the surface has been well explored and several ore-bodies exposed. There are two nearly parallel leads on this claim, separated at the eastern end by about 100 feet and at the western end by about 40 feet. The leads run nearly south-east at the centre of

the claim, but turn round toward the ends into a nearly east-and-west direction. They have the usual northerly dips. British Columbia—*Cont.*

"The principal ore-body on the southern or main lead, occurs 500 feet east of the western end of the claim, and has a maximum width of from 8 to 9 feet and a length of from 100 to 150 feet. A shaft has been sunk to a depth of 50 feet, passing through solid ore all the way. At 250 feet west of the shaft, a second ore-body, 5 to 6 feet in width, has been uncovered, while near the eastern end of the claim a third occurrence of ore, 4 feet wide in places, has been traced for 100 feet.

"The 'War Eagle' ore is similar in character to that of the 'Leroy,' and is stated to average $36 in gold to the ton.

Other mines.

"Considerable work has also been done on the 'Centre Star,' supposed to be a continuation of the 'Leroy,' on the 'Nickle Plate' and on the 'Josie,' the former lying to the south and the latter to the north of the 'Leroy,' but at the time of my visit all three were idle from various causes. At the 'Josie,' besides the ordinary iron and copper sulphurets, mispickel also occurs. A large quantity of ore has been shipped from this mine.

"Half a mile north of the 'Leroy,' is the 'Cliff' mine, one of ten claims, all supposed to be situated on the same lead. This mine is owned by Wharton, Bros. & Cook, and was located in 1890 by Gay Reeder. The principal openings consist of a tunnel 45 feet long and a shaft 20 feet deep, situated 150 feet west from the mouth of the tunnel. The tunnel follows ore all the way, the ore-body being narrow at the entrance, but gradually widening, until at the end, the tunnel is entirely in solid ore. At the surface, above the end of the tunnel, 12 feet of ore is exposed. The ore in the tunnel is mostly pyrrhotite with some copper-pyrites and is reported to carry gold to the value of $8 to $9 to the ton. At the shaft the ore-body is smaller, varying from 4 feet at the surface to 2 feet at the bottom, but the ore is stated to be much richer, running from $25 to $27 to the ton.

"A large number of other claims, some of which show considerable bodies of ore, have been staked out in this neighbourhood, but it is impossible to give an account of these in this short summary.

Goat Creek.

"West of the main Trail Creek camp, on the west bank of Goat Creek are the 'O. K.' and 'Gold Hill' claims, two mines, of an entirely different character from those just described. The 'O. K.' was discovered in 1892 by John Y. Cole, one of the present proprietors. It consists of a gold-bearing quartz vein, running in a direction a little south of east through a compact, greenish, partly serpentinized rock, probably an altered eruptive. A tunnel following the lead has been driven in

British Columbia—*Cont.*

for 300 feet. The quartz varies in thickness from a few inches up to 2 or 3 feet, and is remarkably rich in places, picked specimens often showing numerous flecks of free gold. Besides the free gold, considerable quantities of iron, copper and lead sulphurets all carrying gold are also present. A car load of assorted ore from this mine, ran $178 per ton, and the average yield is stated to be about $38 per ton. A five-stamp mill is in operation here.

"The 'Gold Hill' mine, owned by Welsh & Morris, is situated a couple of miles north of the last. The opening made on this, is a shaft 30 feet deep, sunk in a nearly vertical porphyry dyke which cuts black slates. The dyke is traversed by irregular quartz veins carrying gold, which do not appear to enter the slates. Ten tons of ore have been shipped from this property and about as much more awaits shipment. The ore was expected to average $120 to the ton.

"In the preparation of this summary of the season's work, I have been obliged to depend entirely on my field notes, as none of the numerous mineral and rock specimens collected have yet been assayed or examined in the office."

The cost of the season's exploration by Mr. McConnell was $1,400.

North-west Territories and Keewatin.

North-west Territories and Keewatin.

In the last Summary Report, mention is made of the exploration conducted by Mr. J. B. Tyrrell in the tract of country lying between Athabasca Lake and Hudson Bay, including the hitherto almost unknown "Barren Grounds" of the north. Mr. Tyrrell did not return to Ottawa in time to furnish a report on his work for publication with others of the same year, and it is therefore considered advisable to introduce his preliminary report here, although it relates to the year 1893.

Mr. Tyrrell's expedition of 1893.

Mr. Tyrrell was accompanied by his brother, Mr. J. W. Tyrrell, as assistant, topographer and Eskimo interpreter. He engaged three Iroquois Indians of Caughnawaga, Q., and a fourth man from Prince Albert, as canoemen. The party thus constituted, and provided with two Peterborough canoes, proceeded to Edmonton, Alberta, by rail. From this point Mr. Tyrrell gives the following account of the expedition :—

"At Edmonton we obtained our supplies for the whole season, and had them, with our canoes and party, transported in wagons to Athabasca Landing, where our journey by water was to commence. The bulk of our supplies were there put in the Hudson's Bay Company's steamer 'Athabasca' to be freighted down to Fort Chippewayan,

while we proceeded down the river in the two canoes. At Fort McMurray we were met by two men with a canoe, from Fort à la Crosse, and our party now consisted of eight men, all told, in three canoes. North-west Territories.

"At Fort Chippewayan we were obliged to wait several days for the steamer to arrive with our provisions, but it pulled in to the wharf on the evening of the 20th of June. The following day was spent packing everything in waterproof bags ready for a final start. My chronometer had been rated at the observatory in Toronto, but I took advantage of the delay to rate it again here.

"On the morning of the 22nd of June we loaded our canoes with provisions almost down to the gunwales, and started the survey of the north shore of Lake Athabasca with solar compass and boat-log, checking our distances by observations for latitude and longitude. Huronian rocks were found in several places, and associated with one of these occurrences is an extensive deposit of iron ore, consisting of hæmatite and limonite. Athabasca Lake.

"At Fort Chippewayan, Dr. McKay, of the Hudson's Bay Company, had induced an Indian named Moberly to accompany us and show us the way as far as the height of land north of Black Lake, but after trailing along behind us with his family to a winter house of his own at the east end of Lake Athabasca, he refused to go further, and we were obliged to proceed without guides or local assistance of any kind. Moberly had been a considerable drain on our stock of provisions, and had spent the evenings telling the other men of insurmountable natural dangers which they would encounter, and of the fierceness of the Eskimo who swarmed through all that northern country, until he had them about ready to refuse to accompany us any further. His desertion was therefore an advantage to us rather than a hindrance. Four days and a half were spent crossing the two long portages west of Black Lake, and on the evening of the seventh of July we paddled to a point on the north side of this lake, where a portage, on an Indian hunting route, leads off to the north. This route had been discovered in 1892, when I was making a survey of Black Lake, and an Indian who accompanied me in that year, said that it led northward to the height of land, beyond which was a large lake that emptied northward, and that the river which flowed from it ran to 'Tobon' Lake, near the country of the Eskimos, where the Indians used to go in pursuit of caribou many years ago. He also drew a sketch of the route up to Daly Lake, north of the height of land, beyond which he did not know. Black Lake.

North-west Territories—*Cont.*

"We carried our canoes and goods across this portage, which proved to be two miles and a quarter in length, and then crossed six small lakes, and an equal number of portages to Chipman or Wolverine Lake, through which the Chipman River flows on its way to Black Lake. More than a day was spent in this lake looking for the way, after which we ascended Chipman River through Birch Lake to Selwyn Lake, a long but very irregular body of clear water.

Height-of-land.

"On July 18th we reached the height of land, where a portage, a mile and a quarter in length, forms the Indian highway from Selwyn to Daly Lake and the northern edge of their present hunting grounds. On the shores of Daly Lake, the forest became thin and intermittent, poplar being here seen for the last time on our journey northward. After considerable search and some loss of time, we found the outlet of the lake, where a stream, called by the Chippewayan, the Telzon, or 'wide shallow river,' flows from it towards the north. On July 22nd, we began the descent of the stream, which either rushed down heavy rapids or widened into lakes thickly studded with islands. In these lakes it was necessary to follow the crooked winding shore in order to find the outlet, while it was always essential to land at the head of a rapid in order to decide on the proper channel down which to run the canoes, or to determine where to make the portage.

Telzon River.

"Five weeks had now passed since we left Fort Chippewayan, and our provisions were disappearing rapidly, for we had seen no game that we might add to our stock from time to time. On the morning of the 29th, while paddling through a small lake, we saw an immense herd of caribou on its eastern shore, standing in a low, wet, grassy bog near the water, at the foot of a long, stony slope. We went ashore and shot a number of bucks, and as there was here a small scattered grove of stunted black spruce and tamarack, the next three days were occupied in cutting up and drying meat for the rest of our trip. While the men were thus busy, I secured a number of photographs of the herds of caribou, and afterwards built a cairn on the summit of a conspicuous hill, and deposited under it a brief record of the trip up to that time.

"On August 2nd, we continued down the river, over heavy rapids, and across small lakes, until on the evening of the 5th, just as a dense fog settled over us, we came to, and camped in, a small grove of stunted black spruce bushes, which proved to be the last wood on the river. The next morning, as I looked from the top of a hill behind our camp, I saw a great lake lying before us of which the surface appeared to be almost covered with a solid sheet of ice.

"Our journey by water seemed to be at an end, but on descending to the mouth of the river, a narrow lane of open water was found between the land and the thick ice, and on this water we travelled in the lake for 117 miles, being in one place obliged to portage across a a point against which the heavy ice was jammed.

North-west Territories—*Cont.*

"The weather had now become very cold, wet and stormy, so that we were two weeks in travelling the above 117 miles, for six days of which time, however, we were prevented by snow, rain and wind from putting our canoes into the water.

Geological formations.

"All the way from Black to Doobaunt Lake, a distance of 404 miles by our line of travel, the country was almost entirely underlain by red and gray gneisses of Laurentian age, although at one place, on a small island in a lake not far from Doobaunt Lake, an outlier of unaltered fossiliferous Cambro-Silurian limestone was discovered. But in Doobaunt Lake the character of the rock suddenly changed. We here found red and gray sandstones and coarse conglomerates, cut and altered by dykes and masses of dark green trap and bright red quartz-porphyry, forming an aggregation of rocks very similar to those of the Keweenawan or upper copper-bearing series, of Lake Superior, and probably of the same age. The red quartz-porphyry is a highly characteristic rock of the Lake Superior beds. These beds are also undoubtedly similar to, and are probably a continuation of the sandstones and traps on the Coppermine River, which have long been known to contain native copper. On the north shore of the lake there is also an outcrop of white Huronian quartzite.

River below Doobaunt Lake.

"Below the lake, the river flows through a deep narrow gorge, the walls of which are composed of hard conglomerate or dark-green trap, holding crystals of amethyst. Past this rapid, we were obliged to carry our canoes over a portage two miles and a half in length, to a small lake on which there was a good deal of ice. From the foot of this portage, the country becomes much more sandy, the hills being generally long sandy ridges, while sandy terraces, possibly marine, extend up their sides to a height of one hundred and twenty feet.

Eskimos.

"On the evening of August 19th, the same day on which we left the portage, we saw a solitary Eskimo deer-skin tent on the top of the right bank, ten feet above the river. Soon we saw the people running about, and it became evident that the camp was in consternation, for we were coming from the land of the Chippewayans, the hereditary enemies of the Eskimos. But the call *Chimo*, *Chimo*, brought an answer from the tent, and a tall fine looking man, still shaking with nervousness, came out to meet us. A present of a plug of tobacco set

Keewatin.

him a little more at his ease, and sent his two wives and six children into the tent looking for a pipe. When the pipe had gone round, and some trifling presents had been given to all the members of this dual family, we obtained a rude sketch of the river to its mouth in Hudson Bay, but where it opened into the Bay he could not tell us. He said, however, that we would meet plenty of Eskimos on the river below. The next day we came to a lake lying among hills of boulders, with a very few exposures of the underlying red quartz-porphyry on its shores. We paddled hard against head winds along its shore for two days, and at length came to the river, at the foot of a beautifully terraced hill of white Huronian quartzite. The weather was constantly rough and cold, with heavy north winds, and occasional showers of drizzling rain. The next day we passed to the west of the terraced ridge of hills, 300 feet high, and paddled against head wind down the swift river between little ridges of boulders. Once we were obliged to make a portage a quarter of a mile in length. Small willows were now very scarce, and when the reindeer-moss was wet, as it often was, we were unable to make a fire without the assistance of a little alcohol.

"Groping our way through another lake, we found the river flowing off toward the north-west, between sandy banks, with a current of three miles an hour. To the right, high bare hills of reddish-green, fine-grained trap rose from 300 to 400 feet above us, while to the left extended an undulating grassy plain. Portages had to be made, here and there, past heavy rapids. After widening for a short distance, the stream suddenly narrowed to a swift rapid between walls of bright red quartz-porphyry, and then entered a gradually deepening channel of red bouldery till, which extends to another rapid, where a portage was made over a hill of the bright red porphyry. This rock is quite massive, but is much jointed, and decomposition has run along the jointage planes, with the development of a green crust.

Branch from the west.

"On the evening of August 25th, the river broke up among sandy hills and islands, and a large branch appeared to flow in from the west. On the banks clumps of willows were growing, and a great quantity of drift-wood was scattered about, among which were trunks of white spruce a foot in diameter, limbs of black poplars, &c. These had doubtless been brought down the west branch, which must be fairly well wooded and at the same time have few lakes on its course to arrest the driftwood.

"The river now turns sharply eastward, and flows through a country underlain by red sandstone and hard conglomerate, to approximately longitude 98° 30′, where hills of Laurentian gneiss again appear to the north. The stream then continues to flow along the contact of the

sandstone and the gneiss for forty miles, where it turns abruptly northward, and flows over a ridge of gray gneiss, forming a heavy rapid, down which we were obliged to run the canoes one at a time. The river here swings round to the south-east, and with a swift current of six or seven miles an hour enters a gradually deepening valley, the sides of which are composed of light green Huronian schists, cut by dykes of dark green diabase, and veins of quartz, calcite and fluorspar, associated with masses of pyrite. Descending this river for thirty-five miles, we passed two small camps of Eskimo and reached the west end of Baker Lake on the second of September. Keewatin—*Cont.*

"Our journey through the unknown interior country was now accomplished, for we had reached a point which had been visited by two old sea-captains in the eighteenth century, although it had not been by any means accurately located by them. We had surveyed a line of 810 miles in length through the very middle of the area which we had been sent to explore. Of this distance 538 miles was through lakes, where the distances were measured with a boat-log, and the bearings taken with a solar or prismatic compass; 272 miles was on rivers where the distances were estimated and the bearings taken with a prismatic compass. These distances thus obtained were constantly checked by observation for latitude and longitude. The lengths of the portages were obtained by pacing.

"The stormy weather of autumn had now set in, and often prevented us from launching our canoes for several days at a time. For the past month caribou had been plentiful in the country through which we were travelling, so that we had no difficulty in obtaining an abundant supply of fresh meat, but they now became very scarce, and on September 3rd we shot the last deer of the season.

"The survey with solar compass and boat-log was continued along the north shore of Baker Lake, which was found to lie on the line of contact of the gneisses to the north, and the red conglomerates to the south. Both rocks were cut by many dykes of red and green trap, while in the gneiss was found a band of red crystalline limestone. The Keweenawan sandstones and traps, similar to those which are so rich in native copper on Lake Superior, had now been traced for 225 miles across country as the crow flies, but the necessities of rapid travel prevented us from giving them more than a very hasty examination. Baker Lake

"At the head of the river flowing from Baker Lake, we met the incoming tide, and as the currents in Chesterfield Inlet were thereafter very irregular, we were unable to use the boat-log with any degree of

Keewatin—*Cont.*

accuracy, so that the remaining distances were estimated, checked by observations for latitude and longitude.

Chesterfield Inlet.

"Chesterfield Inlet was found to be a fiord-like body of water, with banks of red and gray granite and gneiss. The mouth of the inlet was reached on the 12th of September, two months and twenty-two days after leaving Fort Chippewayan.

"We now began the heavy task of travelling down the tidal shore of Hudson Bay in our little open canoes For the first three days the weather was beautifully fine, and we covered more than a hundred miles of the distance, but then storm after storm broke over us, and in the next twenty days we made only 120 miles, an average of six miles a day. The survey had been kept up to this point and the shore had been found to be composed very largely of dark green Huronian schists and quartzites, almost everywhere studded with minute grains of copper-pyrites and cut by quartz veins.

West coast of Hudson Bay.

"On the 22nd of September the ground was covered with a heavy fall of snow, and on the 25th we walked twenty miles, often on the crusted snow, to the mouth of a river in search of caribou, but we were only able to shoot one ptarmigan, which we divided for dinner. Our provisions were now entirely exhausted, and had not one of the men had the good fortune to shoot a polar bear we should certainly have starved to death. On the 6th of October the winter had settled down on us, and even in the sun at midday the thermometer seldom rose above freezing point. We were without food or fuel, and many of our clothes were worn to rags. Two hundred and fifty miles of shore still lay between us and Fort Churchill, the nearest point where we could obtain supplies. Our canoes were loaded with specimens of rocks and minerals which we had collected both in the interior and on the coast.

"It was clearly impossible to reach Churchill travelling as we had been, and I therefore decided to leave everything behind which was not absolutely necessary for the safety of the party. The shore was a vast snow-covered plain, but a slightly gravelly eminence was chosen, half a mile from high-tide mark, and on it, one canoe, all our rock specimens, instruments and whatever else was not necessary for our existence, were carefully piled in a heap and covered with tarpaulins. Our note-books, photographs and collection of plants, with guns, ammunition, blankets, and two tents, were put in the remaining two canoes, and thus lightened, and with four men with paddles in each canoe, we started southward again, determined to reach Churchill by water if possible.

"The shore was very low and flat, and at low tide the water was generally several miles from the line reached by it at high-tide, so

that we were able to land or launch our canoes but once in each twelve hours, at the time of high tide. Any rocks seen on the shore were Laurentian granites and gneisses. Keewatin—*Cont.*

" We struggled onward for ten days, living on what few ducks we could shoot in the open water. The weather was very cold and the water that was splashed over us by the wind constantly froze on our clothes and hands. When night came on, on the 14th of October, it was ebb-tide and we were out among ice and boulders almost out of sight of land. That night we spent in our canoes, one of the men having both his feet badly frozen, while another was very ill with dysentery. On the afternoon of the 15th we gained the edge of the solid ice, and hauled the canoes over it to the shore, where we pitched a tent just as a heavy storm of wind and snow broke over us. There was now driftwood on the shore, and with it we made a fire and cooked some ducks that we had shot, getting the first food that we had tasted for thirty-six hours.

Fort Churchill.

" Assured that we were now not very far from Churchill, I sent two men on foot through the snow to the fort for assistance. On the afternoon of the third day they returned with dog-teams, bringing us pork and flour, and on the 19th of October we were carried to Churchill. Here we obtained shelter with the clerk in charge for the Hudson's Bay Company, and we received every kindness from Rev. J. Lofthouse, the missionary to the Eskimo for the Church Missionary Society, but fresh meat was not to be had, and the men gained strength very slowly on the limited diet of salt pork, flour and oatmeal.

Fort Churchill to York.

" We remained here until the 6th of November, when we crossed the Churchill River on the new ice and started on snow-shoes for York Factory. We had secured one dog-team from the Hudson's Bay Company, to carry our provisions and the man whose feet has been so badly frozen, while the other men were obliged to haul their bedding on small toboggans. Other dog-teams belonging to the Hudson's Bay Company assisted us for part of the way, as they were going to recover some stuff that had been left on the shore between York and Churchill by one of their officers in the latter part of September.

" When we arrived at Nelson River, the scanty supply of provisions which we had been able to obtain at Churchill was exhausted. The river was found to be full of running ice, so that we were unable to cross it either in the boat, which we found there, or on the ice, and our party, now augmented by three local Indians, was obliged to remain on its bank for ten days, subsisting on the few rabbits, foxes, etc., that we were able to catch. The weather had been very cold, the thermo-

Keewatin—*Cont.*

meter often falling at night to 20° F. On the 24th of November we arrived at York Factory, where we were able to procure a plentiful supply of provisions. Dr. A. Milne is the officer in charge here for the Hudson's Bay Company, and as Michael, the man with frozen feet, was unable to walk, and we were unable to obtain transport for him, we left him under the doctor's care, to be sent out with the winter packet.

Fort York to Winnipeg.

"Here we obtained another dog-team, and provisions for twelve days, and on the 28th of November started through the deep unbroken snow for Oxford House, 250 miles distant. The country passed through was generally flat and swampy, thinly wooded with small black spruce. Late on the evening of December 7th, we arrived at Oxford House, rather tired and footsore after our ten days' walk. After a delay of six days, waiting for a relay of dogs, we again started, and arrived at Norway House on the 20th of December. Here the men from Isle à la Crosse and Prince Albert were paid off, and sent home by way of Cumberland, while I obtained fresh dog-teams and drove southward across Lake Winnipeg to Lower Fort Garry, where we arrived on the evening of the first of January. After remaining in Winnipeg a few days to settle with the Hudson's Bay Company, I proceeded to Ottawa, where I arrived on the morning of January 11th, having been absent eight months and five days.

Distance travelled and surveyed.

"During this time we travelled, beyond our railway journey, 3,200 miles. In this distance the following surveys were made:—770 miles over lakes, where the distance was measured with a boat-log, and in order to avoid local attraction, or the weakness of the magnetic needle, the bearings were taken as much as possible with a solar compass; 272 miles of rivers and 360 miles of the coast of Chesterfield Inlet and Hudson Bay, where the distances were estimated and the bearings taken with a prismatic compass, the variations being constantly determined with the solar compass. Throughout all the above distance, observations were taken with the sextant and artificial horizon as often as possible, both for latitude and longitude. 250 miles more of the shore of Hudson's Bay was geologically examined. Of 200 miles travelled on foot from Churchill to York, a careful track-survey was kept, the bearings being taken with a prismatic compass. For 400 miles travelled on foot from York to Norway House, a record was kept of the geology, forests, &c., of the country passed through. For 948 miles the country had previously been travelled over and reported on by officers of this Survey or others.

"A collection of 230 species of plants was made, and 256 photographs were taken during the expedition."

In the spring of 1894, Mr. Tyrrell was authorized to undertake a second expedition through the "Barren Grounds" by another route, starting from the north end of Reindeer Lake, and proceeding thence, by whatever way might prove to be practicable, to the west coast of Hudson Bay. He was accompanied by Mr. R. Munroe Ferguson, who bore his own share of the expense of the journey. The party did not return to Winnipeg till January 7th, and it is thus possible to include only the following brief outline of the work done. Mr. Tyrrell writes as follows :— North-west Territories and Keewatin.

"On June 9th we started for Winnipeg, where arrangements were made with the Hudson's Bay Company for obtaining supplies from any of their trading posts at a certain fixed rate. His Honour Lieut.-Governor Schultz, also gave us a large birch-bark canoe to accompany us through part of the distance. With the assistance of Mr. William Clarke, four men were engaged, and on June 16th we left Selkirk and crossed Lake Winnipeg, arriving at Grand Rapids on the 22nd, and Cumberland House on the 2nd of July. On July 4th we left Cumberland, and on July 18th reached Du Brochet trading post of the Hudson's Bay Company, at the north end of Reindeer Lake, having travelled 600 miles in our canoes since leaving Grand Rapids, making such geological investigations as the time at our disposal would permit. Here we secured two Chippewayan Indians as guides, and began our regular survey with compass and boat-log. We ascended Ice River for seven days, and then left it and travelled through Thanout and Theitaga Lakes, which discharge their waters by Thlewiaza River into Hudson Bay, passing through Nooeltin or Island Lake. Winnipeg to Reindeer Lake.

"On August 5th we reached Kasba Lake, at the head of Kazan or White Partridge River in north latitude 60° 10′, having travelled 221 miles from Reindeer Lake, in which distance there were fifty-three portages, with a total length of 15·75 miles, across which our canoes and provisions had to be carried, usually necessitating four trips on each portage. The east shore of Kasba Lake was surveyed, and the river for a short distance down to Ennaida Lake, which lies on the edge of the Barren Lands. Here our Indian guides turned back, and we proceeded northward, until on August 17th we reached a camp of Eskimos. The next day we hired two Eskimos to accompany us down to the shore of Hudson Bay, thus relieving us of any uncertainty as to our route. We followed the river for two weeks, passing a large number of Eskimo camps, exploring the west shore of Yath-kyed Lake on our way. When in north latitude 63° 7′ we learned definitely that the river flows into Baker Lake, at the head of Chesterfield Inlet, Kazan River.

North-west Territories and Keewatin—*Cont.*

but by a series of long portages we should be able to reach a river flowing into Hudson Bay much further south. We crossed the portage with the help of seven Eskimos, and in spite of continuous storms of rain, snow, and wind, descended the river, reaching Hudson Bay about north latitude 62° on September 18th, just three days earlier than we had reached the same point last year. Fine weather now set in, and continuing our journey down the shore in our two canoes, we reached Fort Churchill on October 1st. The winter had now begun, and further travel in canoes was impossible. We were therefore obliged to remain here until the ice had set fast on the rivers and lakes. During our detention, the surveys up to that date were plotted, ready for reducing on a map, the quartzite rocks of the vicinity were carefully examined, and a collection of fossils was made from the Cambro-Silurian limestones.

Churchill to Winnipeg.

"At Churchill, we purchased from Indians one team of five dogs, hired two Indians with a team of four dogs, and a team of dogs from the Hudson's Bay Company to accompany us for six days. Thus equipped we started on November 28th in a south-westerly direction for Split Lake, provisioned for fourteen days, taking the route that may hereafter be followed by the Hudson Bay Railway. We reached Split Lake in eighteen days, having made a track-survey throughout the distance from Churchill, and on December 23rd we reached Norway House. Thence we continued our tramp to Dog's Head, Lake Winnipeg, at which place we took conveyances and drove to Selkirk, where we arrived on the evening of January 7th.

"The route followed from Reindeer Lake to Hudson Bay was 815 miles in length, of which 303·5 miles was measured with boat-log, 480 miles estimated, and 31·5 miles, over 81 portages, paced. 1,700 miles in all were travelled in canoes. A track survey was made on snow-shoes for 275 miles from Churchill to Split Lake, the total distance travelled between Churchill and Winnipeg being 725 miles."

Ontario.

Nipigon Lake. Messrs. McInnes and Dowling.

Mr. W. McInnes spent the earlier part of the year 1894 in compilation work in the office, in connection with sheet No. 9 of the series of Rainy River and Thunder Bay district maps, and in working up the geological notes of the past and previous seasons. The notes of the late Mr. W. H. Smith, on sheet No. 6 of the same series, were gone over, and from them the geological boundaries were laid down on that sheet. It seemed advisable that the report on the geology of the district covered by sheet No. 6 should be included in that on sheet No. 9, and work on the combined reports occupied the remaining office time.

During the past summer Mr. McInnes and Mr. D. B. Dowling were engaged in making a survey and geological examination of Lake Nipigon in Western Algoma. No work had been done in this region since the exploration of Dr. Bell in 1869, the results of which appear in the Report of the Geological Survey for 1866-69 with supplementary notes published in the report for 1871-72. The design of the present exploration was that it should serve as a basis for a more detailed geological and topographical map of the region. Ontario.

Mr. McInnes reports as follows on the work of the summer :—

"Leaving Ottawa on the 12th of July, my time was employed, until the arrival of Mr. Dowling on the 30th of July, in examining the various sections exposed along the line of the Canadian Pacific Railway and about Nipigon Harbour. Near Loon Lake, the basal beds of the Nipigon (Keewanawan) series were found to lie in a horizontal position on the upturned edges of the Archæan gneisses. The lowest bed is here a conglomerate with paste of quartz and felspar and pebbles of gneiss and of various schists and diorites of the Huronian (Keewatin). The valleys between the rounded hills of Archæan are filled with drift material showing, however, the horizontal beds of the Nipigon series protruding in many places. The actual contact of the two sets of rocks was seen in only a few places, where patches of the conglomerate were left clinging to the sides of the rounded hills of gneiss. The relationship of the two, clearly indicates, not only an unconformable overlap of the conglomerate, but also that the rounding of the Archæan in its broad aspects was finished before the Nipigon rocks were laid down.

"On the arrival of Mr. Dowling, a party was made up for the purpose of carrying on the regular work of the summer. A survey with transit and Rochon micrometer telescope was made of the shores of the lake, and this was connected with the line of the Canadian Pacific Railway and Lake Superior by a line carried along the river between these points. Mr. Dowling, assisted by Mr. W. Lawson, did the instrumental work and took general charge of the surveying. Smoke from forest fires in the country south of Lake Superior hampered the work very much, coming up with the prevailing southerly winds in such density as to make work with the instruments difficult and the fixing of many of the islands in the lake impossible. The work of the season was necessarily carried over much of the ground already reported on by Dr. Bell in 1869, and little has been added to his work except in matters of detail. It may be interesting, however, particularly as the report referred to is out of print, to make some general remarks about the lake. Surveys carried out.

Ontario—*Cont.* Nipigon Lake.

"The lake has a very irregular shore-line with deeply indented bays and irregularly jutting points. Its greatest length from north to south is about sixty-five miles and greatest width forty-five miles. The lake lies in a trough, excavated in rocks of the Nipigon (Keewanawan) series and in the traps which cut and overflow these sediments, the Nipigon rocks having themselves been laid down in an older basin in the Archæan gneisses and schists.

"Its depth is probably great, and would seem from the evidence of the inclosing rocks to be largely defined by the depth of the original old hollow in the Archæan surface. The thick smoke which was so prevalent during the summer, made it impossible to make a satisfactory series of soundings, but at a point about two miles and a half south-west of Livingston Point, a depth of over four hundred feet was found. The water everywhere in the main lake is very clear and cold, though every stream of any considerable size entering the lake is quite dark in colour. This dark colour extends only for a short distance out in the immediate bay into which each of these streams empties, the churning of the waves apparently bringing about a bleaching which within a short distance renders the water colourless.

"About the southern and south-western shores, the traps form most of the points and border many of the bays, rising in high, abrupt cliff-faces from the shore-line, and reaching heights of over 500 feet above the water-level.

Rocks exposed.

"Nowhere about the lake are the sedimentary rocks of the Nipigon series seen in any great volume. The mass of the strata exposed about the shores and forming the high bordering hills, is trap, with only here and there a thickness of from six to fifteen feet of limestone or sandstone underlying it at about the water-level. On the southern and south-western sides of the lake, limestones are the only sediments met with, and on the southern and north-eastern sides, highly siliceous red and white sandstones (which become, locally, quartzites), take the place of the limestone under the trap. These sandstones lie directly upon the Archæan gneiss and seem to be littoral beds which mark the shore limit, in this direction, of the basin in the deeper part of which the limestones were deposited.

"Along the northern and eastern sides of the lake, the immediate shores are occupied largely by the gneisses, schists and greenstones of the Archæan, which everywhere show the highly altered character and nearly vertical attitude so generally characteristic of these rocks elsewhere. Along the eastern shore, alternating broad bands of Laurentian gneiss and Huronian (Keewatin) schists and greenstones, strike north-easterly. They are not continuously exposed, the trap still

covering them in many places and forming most of the prominent points, underlain at a number of places, as far south as the south side of Livingstone Point, by the flat-lying sandstones of the Nipigon series. Ontario—*Cont.*

"No minerals of economic value were found in commercial quantities. On the east shore, near Poplar Point, a fibrous form of serpentine, approaching asbestus, occurs in very much broken veins, cutting intrusive serpentinous rock of the Huronian, but where seen it was not commercially valuable. Some of the sandstones, limestones, &c., about the lake would afford good building stone. Evidences of glaciation are well marked and widespread about the lake. Polished and grooved surfaces are very common and indicate two periods of glaciation, an earlier from north to south, and a later from east to west, or in places from north-east to south-west. That this westward-moving glacier was the later of the two, is clearly shown in many places by the striæ and grooving of the one overriding and planing out those of the other, and leaving only isolated patches of striæ on a few protected surfaces. Glaciation.

"Land suitable for cultivation is found about the heads of many of the bays on the south side, notably McIntyre's Bay, where, at the English Church mission, the Indians have several acres under cultivation, and successfully grow potatoes of fair quality. At Jackfish Island, near the west shore, the Indian school master, who is an enthusiastic horticulturist, succeeds very well with all the common garden vegetables. Arable land.

"There is little good timber in the immediate vicinity of the lake, though an area of good pine is reported on Pijitiwabikong Bay, and white spruce of fair size is sparsely scattered about the shores of the lake almost everywhere.

"The Nipigon River has long been famous as a trout stream. The brook trout are probably unexcelled anywhere for size and numbers, running up to weights of five to seven pounds and over. They are not confined to the river, but are caught in the main lake itself, a fact which renders their extermination by legitimate fishing in the river practically impossible In addition to brook trout the principal food fishes of the lake are lake trout, pike and white-fish, all of which are abundant. Fish.

"The scenery along the river is grand and varied, and the stream is easy of ascent by canoe, with rapids and falls at intervals along its course, which are wild enough to make a summer excursion interesting without being dangerous."

Cost of the season's explorations, $981.57.

Ontario—*Cont.* District of Algoma. Work by Dr. Bell.

Dr. R. Bell was engaged during the summer in geologically examining the country to the north of Lake Huron. The objects in view were to complete the delineation of the boundaries between the various classes of rocks within the limits of sheet 129, or the "North Shore Sheet," and, if time permitted, to determine certain points about which some uncertainty existed in reference to some of the geological boundaries in sheet 128, or the "St. Mary's River sheet." Dr. Bell makes the following preliminary report on this work :—

"Owing to the delay in obtaining funds, it was the 16th of July before I left Ottawa, and on the 17th I reached Spanish River, which I again made my basis of operations for sheet 129, and later in the season I proceeded to Sault Ste. Marie. On my arrival at Spanish River I was joined by Mr. H. G. Skill and Mr. R. W. Brock, who were again to act as my assistants. Owing to the smallness of the fund placed at my disposal, I was only able to engage, in addition to these gentlemen, a cook and one or two canoemen, from time to time, as they were required.

Boundaries to be ascertained.

"It was stated in my summary report for last year, that the northern part of sheet 129 was occupied by a continuation of the red granite, which is so extensively developed in the western part of the Sudbury sheet; but part of the boundary within the present sheet between this granite and the other rocks to the south of it remained undefined. One of our first objects was, therefore, to endeavour to complete the tracing out of this boundary. The geological age of the granite in question has not been definitely settled. A discussion of the relative ages of the granites and the banded Huronian rocks with which they are here in contact, would be out of place in the present report. While the granites may have received their present condition or form subsequently to the consolidation of the stratified Huronian rocks, they nevertheless appear to be continuous with and to merge into the recognized Laurentian gneisses and granites occupying the great region to the northward.

"In 1893, I had ascertained that the quartzites and other Huronian rocks extended for about fifteen miles to the northward of Ten-mile Lake, which is in township 156. What appeared to be an extension of these rocks to the eastward was met with in township 139, leaving a tongue or spur of the granite between them and the main area of the Huronian to the southward. In order to ascertain whether any of the Huronian rocks were to be found still further north, I sent Mr. Brock with an Indian guide, from Massey, with instructions to trace it out and to go, if necessary, as far north as Lac aux Sables. He explored the ground all the way to this lake and found everywhere only

the same red granite. The country occupied by this rock is here, as elsewhere, extremely rough, rocky and bouldery, with swamps between the ridges, and the woods were everywhere difficult to penetrate.

Ontario—*Cont.*

"The region along the northern line of the sheet is all of the character just described. No roads or trails have been cut into it and it is almost inaccessible by canoe from the south. From what I had heard of the country lying between it and the Canadian Pacific Railway, I thought it likely that the district on or near the above line might be reached by following a canoe-route from Biscotasing through the upper waters of the Mississagui River. Accordingly I proceeded to Biscotasing, where I obtained a canoe from Mr. T. C. Rae of the Hudson's Bay Company, and after some difficulty I succeeded in engaging two canoe-men, one of whom knew a part of the route I proposed to follow. Leaving the above station on the Canadian Pacific Railway, I proceeded southward, ascending at first Spanish River waters, which were of a dark colour, and then crossing a watershed I continued my course in the same direction, descending numerous clear-water lakes with their connecting streams, all forming part of the head-waters of the Mississagui, until I reached a lake which touches the north line of sheet 129, about thirty miles west of its north-eastern corner. From this lake the general course of my route, which followed the main Mississagui River, was westward at no great distance north of the above line until I had passed the north-west corner of the sheet, when it turned to the south and then to the south-east, traversing the south-western part of its area. I made a careful track-survey of the whole of my route from Biscotasing to the shore of Lake Huron at the mouth of the Mississagui River.

Route by Mississagui River.

"Between the Canadian Pacific Railway and Old Green Lake post, lakes were numerous on our route and also in the country on either side of it. Immediately below Old Green Lake and its connecting ponds and marshes, we passed through a lake five miles in length, and then the general descent of country became more rapid and no more lakes occurred on the course of the Mississagui, which increased constantly in volume by the falling in of numerous branches.

"The rocks on the above route, all the way from Biscotasing to a point on the Mississagui a few miles above Salter's base-line, where we entered upon the great belt of the Huronian series, consist of the red granite already described, and there is no doubt that the whole of the northern part of sheet 129 is occupied by this rock. After coming upon the stratified Huronian rocks at the above point, they were examined all along, and numerous notes recorded in regard to them, in addition to the facts mentioned by the late Mr. Alexander Murray of

Great area of red granite.

Ontario—
Cont.

this Survey, who had ascended the river this far. The red granite area traversed on the above journey and which, as already stated, occupies the northern part of the sheet just referred to, must be of great extent. It is known to extend from the northern and western parts of the Sudbury sheet through the region explored last summer to the Goulais River, and it may connect with the granite areas near the eastern border of Lake Superior.

Projections of granite mass.

"In the centre of sheet 129, a tongue of the red granite runs westward from the main body to the middle of the line between townships 156 and 157, where it terminates. The southern boundary of this tongue has been traced almost continuously from the above termination eastward into township 118, where the Huronian rocks end, having the granite to the north, south and east of them. From this point their southern margin runs westward as far as township 155, from which the boundary drops southward nearly to the eastern part of Lake Lauzon, from which it turns eastward or parallel to the lowest stretch of the Serpent River. A second and wider tongue or promontory of the granite is thus formed, also extending westward from the main mass.

"A third promontory of granite, also pointing westward, occupies the peninsula between Lake Huron and the lower part of Serpent River, with the exception of a narrow belt of gray crystalline schists running along the bottom of the valley in which the river itself flows. This granite differs from most of that to the northward in being finer grained and gray in colour.

"In the south-eastern quarter of the sheet, the granite is much mixed with greenstones. In some sections about one-half of the rock consists of the latter, so that it is sometimes difficult to say whether these should be considered as granite mixed with greenstones or *vice versa*. Wherever the greenstone areas are sufficiently large, they will be shown in their own colour on the map, but otherwise the mixture will be indicated by notes on the granite colouring.

Investigations near Sault Ste. Marie.

"Sheet 128 belongs to the same range as sheet 129 and abuts it on the west. It covers that part of the great Huronian belt, which had been the most carefully worked out by Mr. Murray. Some geological work had also been done within this area by myself in various years since Mr. Murray's operations had ceased. Combining these results, it appeared that the geology of this sheet was pretty well finished, with the exception of that of a small tract north of Sault Ste. Marie. In order to complete this work, I proceeded to the Sault, with Mr. Skill as already stated, in the beginning of September.

"One of the principal points to be determined was whether the gneissic area between the St. Mary's River and Goulais Bay con-

stituted a promontory of the granitic tract to the north-eastward or formed an isolated mass. Our investigations proved the latter to be the case. We found a considerable breadth of quartzites, grauwackes, conglomerates, schists, &c., running north-westward through the township of Jarvis and the north-eastern part of Aweres, connecting the Huronian of Garden River with that of Goulais River and Batchawana Bay. The accomplishment of this work appeared to be all that was necessary in order to render sheet 128 ready for publication in as complete form as is possible at present, or in order that it may compare favourably with the other sheets on the same scale showing the geology in similar regions. Ontario—*Cont.*

"*Economic Minerals.*—I was shown small specimens of galena and plates of mica said to have been found within sheet 129, but I could obtain no definite assurance that they occurred in economic quantities. Gold was also said to have been found by private assayers in samples of quartz taken from veins in different parts of the sheet, but no reliable particulars could be obtained. But I know of no reason why this metal may not exist in promising quantities in such veins, particularly in those which occur among the mixed granite and greenstone rocks. Economic minerals.

"The old Borron Location on the Mississagui River, which was laid off before the township surveys were made, is situated in the southern part of the township of Gould, being in what are now the first and second concessions. On the west side of the foot of the first chute at the head of the Long Portage, on this location, a vein of quartz three and a half feet wide cuts the 'slate conglomerate,' which here forms the country-rock, but which at the head of the next chute, a short distance below, is associated with crystalline greenstone. The vein run- N. 65° W. and carries promising quantities of copper glance, of which a few tons, mined just before my visit, were piled beside a prospecting pit. Two or three smaller veins in the vicinity carried a little copper pyrites.

"After having expended my appropration for the season's operations, before leaving the field, a short time in camp was devoted to compiling and mapping our results, and I was assisted in this work by Mr. Skill. I returned to Ottawa on the 25th of October."

Cost of the season's explorations, $955.25.

Mr. A. E. Barlow, during January and February last, was granted permission to carry on his work in Montreal, where he had the advantages of the co-operation of Dr. F. D. Adams, in the comparative study of the Archæan rocks, of which many interesting and difficult varieties Work by Mr. Barlow.

Ontario—*Cont.*

occur in the region being investigated by him. During this time, over 200 thin sections of these were microscopically examined.

On his return to Ottawa, this petrographical work was continued at intervals, in association with Mr. W. F. Ferrier, and considerable progress has been made in the examination of the one hundred and fifty slides of both typical and unusual rocks within the area included in the Nipissing and Temiscaming sheets (Nos. 131 and 138 respectively) of the Ontario series of geological maps. The remainder of the time before field work was commenced in July, was occupied in reducing and compiling the surveys made chiefly by Mr. J. F. C. Johnston during the previous summer, in which Mr. Johnston assisted.

In regard to the summer's exploration, Mr. Barlow reports as follows :—

Nipissing and Temiscaming sheets.

" I left Ottawa on July 5th, with instructions to collect the geological and topographical details necessary for the completion of the Nipissing sheet (No. 131, Ontario) and to prosecute as much work as possible on the Temiscaming sheet, (No. 138) situated immediately north of the last. A few days were spent at Mattawa examining the numerous rock-cuts necessary for the construction of the new Temiscaming branch of the Canadian Pacific Railway. The mineral cyanite, which had been found in 1890 for the first time in Canada 'in situ,' near Wahnapitae station, was observed to be an abundant constituent of the gray gneissic rocks exposed on this line of railway in the neighbourhood of Les Erables Rapids and Snake Creek.

" Fort Temiscaming, an abandoned Hudson's Bay Company's post, was made our headquarters for the season. Here I was joined by Mr. A. M. Campbell of Perth, who for several years past has proved an energetic and valuable assistant in the summer's exploration.

Lake Temiscaming.

" The country between Lakes Temiscaming and Keepawa was examined, and micrometer surveys were made of a number of lakes and streams, which will materially aid in filling in the topographical features of this strip of country. Soundings were taken to determine, with some degree of accuracy, the depth of Lake Temiscaming, concerning which very many exaggerated statements have been made. The deepest place ascertained by our soundings was about one mile and a quarter south of the mouth of the Keepawa River, where the lead reached bottom at four hundred and seventy feet. The lake maintains a rather uniform depth of a little over four hundred feet from McMartin's Point to within a mile of the Montreal River, where owing to the accumulation of sand and gravel, it is only about three

hundred feet deep. Above this it again deepens to four hundred feet, and opposite Quinn's Point is three hundred and seventy feet in the middle. The bottom of the lake is covered with a very soft clay or mud, into which the lead sinks very readily, except off the mouth of the Montreal River and from McMartin's Point to the Opimika Narrows, where the bottom is covered with sand, or a mixture of sand and gravel with some boulders.

Ontario—*Cont.*

Surveys accomplished.

"The season's work was confined to such geological detail as was necessary for the completion of the Nipissing sheet (No. 131), the geographical position and limits of which have been described in the Summary Report of 1892. Only such topographical surveys were undertaken as seemed necessary for the adequate representation of the geological features. The region to the south-west of the Opimika Narrows, was examined, as well as the townships of Gladman, Hammell, Notman and Lyman. During the latter part of August, the southern part of Lake Temagami was also examined, for the purpose of obtaining greater geological detail than was possible during its topographical survey in 1887. The early part of September was spent in mapping out with greater precision the Silurian (Niagara) outlier exposed on the shores and islands of the northern portion of Lake Temiscaming, and the season was concluded with an examination of the townships of Grant, Field and Badgerow. While absent on this latter exploration, Mr. Campbell made an examination of the Manitou and Goose Islands in Lake Nipissing. The geological and topographical data at hand are now considered sufficient for the completion of the Nipissing sheet, and the Temiscaming sheet is about half finished."

Mr. Barlow returned to Ottawa on October 4th, and has since been engaged in preparing the material for his report and map, and in further petrographical examinations of the specimens from the districts above alluded to.

The cost of the field work was $874.66.

Quebec.

(With adjacent parts of Ontario.)

Work by Dr. Ells.

The winter of 1893-94 was devoted by Dr. R. W. Ells to writing his report on the geology of the area north of the Ottawa and east of the Gatineau, and to the compilation of the map of that district. (Sheet No. 121.)

On the field work accomplished during the past season, chiefly in the counties of Ottawa, Pontiac and Carleton, Dr. Ells reports as follows :—

Quebec—Lower Ottawa.

"During the season of 1894, a few days were spent in June in the examination of certain points along the lower Ottawa, more particularly with reference to the character of the rock masses known as Mounts Calvaire and Rigaud, on either side of the Lake of the Two Mountains. The former of these was found to consist principally of reddish syenite, with masses of a greenish gabbro rock, the latter of syenite and felsite, in places porphyritic, and apparently intrusive through the Calciferous rocks which surround it.

Upper Ottawa.

"On July 10th, the examination of the Upper Ottawa was commenced, canoes being put in at Britannia, and a careful study of the rock sections along the river was made as far west as the Rapides des Joachims, fifty miles west of Pembroke. The country to the north, in Ottawa and Pontiac counties, was examined to a distance inland of from ten to forty miles, and surveys were made of the greater part of the roads in that section. In September and a part of October the country in the more immediate vicinity of Ottawa city was examined. In this I was assisted by Mr. N. J. Giroux, whose field of work adjoins on the south the map-sheet of the Upper Ottawa, the junction of several map-sheets being in the vicinity of this city.

"Comparatively little has been added to our knowledge of the geological structure of the Ottawa River region for many years. In 1853, Mr. James Richardson made an examination of the country along the south side, from Pembroke eastward to Point Fortune, the results of which were incorporated in the large geological map of 1866. In 1876 Mr. L. R. Ord made surveys of a number of roads north of the Ottawa extending west from the Gatineau River to the Coulonge, and Mr. H. G. Vennor also made several traverses in this section, both to the north and south of the river, the report on which is contained in the volume for 1876-77.

Sections along the river.

"The river affords excellent sections of the various formations from the Laurentian to the top of the Trenton, and in many places the intricate admixture of the crystalline limestones and grayish gneisses with the intrusive syenitic, pyroxenic and dioritic rocks can be well studied.

"Between Britannia and the Chats Falls, which forms the first break in the navigation, the rocks along the south shore are divisible into Calciferous and Chazy. The former of these constitutes a belt nearly six miles in breadth, between Britannia and Berry's Wharf, the rock being chiefly a buff-weathering dolomitic limestone. The limestones cross the river and show along the beach on the north shore for several miles above the town of Aylmer, where they are overlaid by green-gray Chazy sandstones and shales. On the south side, these latter extend from below Berry's Wharf to Fitzroy Harbour at the

foot of the Chats Falls, capped on the tops of the hills inland by Chazy limestone, which also appears along the shore in the township of Torbolton, about Buckhams Bay, where the rock has been extensively quarried for building stone. Quebec—Cont

"Further inland, the Calciferous rests upon and passes into the Potsdam sandstone. This flanks, on the north and east, a long tongue of Laurentian gneiss and limestone, which extends south and east from Fitzroy Harbour to within ten miles of the city of Ottawa. These crystalline rocks have associated with them large areas of intrusive syenite and diorite which have broken through the crystalline limestone and associated gneiss.

"At the Chats, the falls and rapids extend for about three miles. They are caused by a heavy dyke of reddish syenite, which here crosses the river as a spur from the great mass on the north side. At their head, the waters of the Chats Lake begin, and from this, with the exception of the small rapid known as the Chenaux, the navigation is uninterrupted to the village of Portage du Fort. The rocks between Fitzroy Harbor and Arnprior, on the southern side of the river, are mostly crystalline limestones of Laurentian age, cut by numerous dykes and masses of reddish syenite and diorite. A band of crystalline dolomitic limestone, with mica, chlorite and hornblende-schists, also cut by diorites, crosses the river in the vicinity of Arnprior and has a breadth westward of several miles. These are a portion of the 'Hastings series,' now recognized as Huronian, and can be traced north of the river to the Bristol Iron Mines, beyond which they are concealed by sandy drift. Portions of their area are also overlaid by thin beds of Calciferous limestones, on the north shore opposite Arnprior and Braeside. Above this, to Portage du Fort, the rock where exposed is mostly Laurentian limestone, forming a series of synclinals, underlaid by rusty gneiss, the whole cut by frequent intrusions of syenite and diorite. Much of the surface north of this, in Bristol and Clarendon, is covered with sand, outcrops of rocks, generally syenite, being rarely seen. At the Portage du Fort village, there is a great development of the crystalline series, the intrusions being particularly well seen, and their action upon the limestone being marked by their alteration of this rock into marble. From certain beds of this locality the marbles employed in the interior of the houses of Parliament in Ottawa were obtained. Chats to Portage du Fort.

"From Portage du Fort to Bryson, a portage of nine miles by road is necessary, the river being broken by rapids and falls. The rocks along this portion of the river consist principally of limestone, but with much syenite intermixed. East of Bryson, a considerable area of the latter Portage du Fort to Allumette Island.

Quebec—*Cont.*

rock occurs, and of Calumet Island, which separates the Bryson Channel from the Roche Fendue, the eastern half is nearly all syenite, except a narrow margin along the river.

"From Bryson west to Coulonge, the north channel shows but few rock outcrops. The banks of the river are composed of sand and clay, while the channel itself is often shallow with numerous shifting sand-bars. These sandy deposits continue up to the Paquette Rapids, which are at the foot of Allumette Island.

"The Roche Fendue Channel, on the south side of Calumet Island, is very rocky, broken by numerous heavy rapids and chutes. The rocks are limestone, underlaid by rusty, gray gneiss, but the syenitic and dioritic intrusions are frequent and masses of the limestone are often caught in the intrusive rocks. The rock on the north side of the Ottawa, between Bryson and the foot of Allumette Island, is mostly syenite. Occasionally small bands of limestone and gneiss are seen, but their area is small as compared with the syenite portion, and they are much broken up.

Allumette Island.

"Allumette Island, and the south shore of the river opposite, are occupied largely by Chazy rocks. The typical Black River occurs at Paquette Rapids, many of the beds being filled with fossils of that formation, which are beautifully preserved. Much of the island, however, is low, and large areas of sand and bog occur inland. The north-west portion is mostly syenite. In the north or Culbute Channel, a heavy rapid is overcome by a lock, while in the south or Pembroke Channel, the navigation is interrupted by the Paquette and Allumette Rapids, the latter about three miles below the town of Pembroke. These, however, can be traversed by steamboats at certain stages of the water.

Des Joachim.

"From Pembroke to Rapides des Joachim the navigation is unimpeded. The surface of Allumette Lake is broken by numerous islands, all of which are of syenite, generally reddish, and this is the only rock seen on either side to the Des Joachim, where our examination ended in this direction for the season.

"The south shore of the lake between the mouth of the Petewawa and Sturgeon Bay, which is at the mouth of Chalk River, is all sand, the banks being in places twenty-five to thirty feet high. The Ottawa for thirty miles below Des Joachim is called the 'Deep River.' The hills on the north are bold, the channel often narrow and apparently very deep. The country in this direction is all syenitic, often without foliation, though this structure is seen in many places. The only trace of limestone seen in this portion of the river, was a thin

crushed band above the narrows about one mile below the mouth of the Swego River, some thirty-five miles above Pembroke. Quebec—*Cont.*

"Some interesting points of structure were observed at various places. While it is very evident that the syenites or granites as a whole, in this section are intrusive in the crystalline limestone, some portions of them are of comparatively recent date. Thus about six miles above the Coulonge, they have apparently disturbed the usually horizontal beds of Calciferous and Chazy, the latter in one place being pushed up along the contact to angles of 36° and 40°; while in the townships of March and Nepean these granites, seen in a cutting on the Arnprior and Parry Sound Railway, have penetrated and altered the Potsdam sandstone of that area. It would almost appear, therefore, that these intrusions do not differ greatly in range of time from those of Mounts Calvaire and Rigaud on the lower Ottawa. Age of intrusions.

"Throughout this district mineral occurrences are rare, or at least have not been developed to any great extent. The Bristol iron mine, in the northern extension of the Hastings rocks, has been idle for some years, though the supply of ore is abundant and the quality good. It resembles very much in character and association the iron ores in the vicinity of Calabogie Lake to the south of Renfrew, which also occur in the rocks of the Hastings group. In character these rocks are almost identical with those found in the Pre-Cambrian range of the Sutton Mountains in the Eastern Townships. On Calumet Island, lots 10 and 11, range IV., there is a very considerable deposit of blende, in places mixed with galena. The ore occurs in connection with diorite which cuts rusty gneiss. Several hundred tons have been extracted, and are piled for shipment, but the force now working is small. Iron ore.

"On the large island below Galetta (Laflamme's Island) a deposit of galena in calcite has been opened up by several shafts. The ore is found in close proximity to a granite dyke which cuts the crystalline limestone, but the mine has been closed for several years. Galena.

"At Quio, on the property of David Ross, lot 7, range III., Onslow, a deposit of ochre occurs, of very good quality, and of considerable extent, furnishing an excellent material for paint. Ochre.

"Mica deposits are found at several places, but generally not of sufficient value to warrant outlay in the extraction of this mineral. At the outlet of Moose Lake, north of Coulonge, several openings have been made in a pyroxene dyke cutting gneiss, but the crystals are very dark coloured and badly shattered. In the vicinity of Carp village, and in the diorites of the Laurentian in the eastern part of March, several of these deposits of dark-coloured mica occur, but the greater number at least are of little value. Mica.

Quebec—*Cont.* Molybdenite.

" A considerable deposit of molybdenite was noticed on the land of Mr. John Gow, south half lot 6, range II., March, in a dyke of felspar which cuts crystalline limestone. A pit eight to ten feet deep has been dug, and specimens of the mineral are seen scattered about the surface. Small quantities of galena are also found in the limestone of this place.

Galena, blende and silver.

" Specimens of galena have been examined by Mr. Hoffman from the townships of Litchfield and Onslow, from the Coulonge and from Calumet Island. That from the Lorne Mine, at the last-named place, yielded 11·666 oz. silver to the ton of 2,000 lbs, and small quantities of native silver also occur in specimens procured from Mr. Russell, the owner of the mine. These come from the quartz and diabase rock at the base of the blende deposit. A specimen of the blende (see p. 63) immediately overlying this, was found to contain a very distinct trace of gold and silver at the rate of 18·229 oz. to the ton. The proportion of silver in specimens from other localities mentioned was unimportant. On the western end of Calumet Island, a band of limestone traversed by a pyroxene dyke carries scattered crystals of apatite, and at a few points traces of asbestus were observed in serpentine, but in none of these was the quantity sufficient to be of economic value.

Great syenite ridge.

" One of the most prominent geological features in the country north of the Ottawa, is the great ridge of red syenite, composed in places almost entirely of flesh-red felspar, which cuts across the strike of the gneiss and limestone from King's Mountain in Hull, north of Ottawa, to beyond the Quio village. This great ridge rises like a wall fronting the Ottawa River to a height of 800 to 1,000 feet, and has a breadth of from six to eight miles, extending almost to the Pêche River in the township of Masham. The syenite is generally massive, without stratification and very often even without foliation. The exposed breadth of the limestone area thus cut off by this mass, is from eight to ten miles, extending from east of Fitzroy Harbour to beyond Arnprior. After passing the great wall of syenite, the limestone comes in again on the Pêche River in Masham township, and continues in a broad uninterrupted belt along the Gatineau River for over one hundred miles to the north. Other areas of syenite and granite, of greater or less extent, also intersect the great belt of limestone, but do not present such prominent physical features as that just described."

Cost of the explorations during the summer, $470.13.

North-East Territory.

(With adjacent parts of Quebec).

Work by Mr. Low.

Early in June, 1893, Mr. A. P. Low left Ottawa for the purpose of exploring the interior of the great Labrador Peninsula, and in this

work, he with his assistant Mr. Eaton, were continuously engaged till September last, when he returned to the office. In the last Summary Report, a letter received from Mr. Low, dated Rigolet, October 5th, was published. This gave a very brief outline of the explorations completed during the summer of 1893. Mr. Low has since prepared the following preliminary account of the results of the expedition, embracing the work of 1893 and 1894:— Labrador Peninsula—

"In accordance with instructions, and for the purpose of carrying out the work with which I had been entrusted, I left Ottawa on the 3rd of June, 1893, accompanied by Mr. D. I. V. Eaton as assistant and topographer. Arriving at Montreal the same day, final arrangements were there made for the shipment of supplies and provisions to Fort Chimo on Ungava Bay, where it was proposed that the party should winter if found convenient, in order to continue the exploration inland early the following summer. Here also, through the kindness of Mr. C. C. Chipman, Commissioner of the Hudson's Bay Company, and of Mr. Peter McKenzie, I was furnished with circular letters to the officers in charge of the posts in Labrador, enabling me to obtain the necessary supplies, information and aid to carry out the work in hand. I may here state, that at all the posts visited, the party met with kindness and attention, and everything possible was done by the officers of the company to assist the expedition. The success of the undertaking has been in great measure due to this assistance. Preparations.

"Two days were spent in Quebec obtaining final supplies, and then we proceeded to Lake St. John, where canoes, provisions and equipment had already been sent. As it is impossible to obtain provisions or supplies of any kind at the Hudson's Bay posts in the interior, and as all the able-bodied men are at this season away to Hudson Bay, engaged bringing in the next season's supplies to the posts, a quantity of provisions sufficient for the whole season had to be taken from Lake St. John, and four men engaged for the entire trip. To transport the provisions, six canoes were found necessary, and four of these were hired by contract by Mr. J. C. Cummins, who also kindly assisted in engaging the other men.

"Lake St. John was left on 17th June, and the Ashuapmuchuan River was ascended to its forks, where the Chef River was followed a few miles to the Sapin Crôche Branch, and that stream to its head in File-axe Lake near the height of land. From there a number of small lakes were passed through in crossing the watershed between the St. Lawrence and Hudson Bay, and then the Perch River, a small stream, was descended to the south-west bay of Lake Mistassini, reaching there 2nd July. The only new exploration along this part of the route Lake St. John to Mistassini.

Labrador Peninsula—*Cont.*

was from the forks of the Ashuapmuchuan River to File-axe Lake, some sixty miles, the lower part having been examined for the Geological Survey by J. Richardson in 1870, and the upper part by W. McOuat in 1871.

"The new portion passed through is traversed by low ridges of gneiss, with small lakes and swampy land filling the valleys between the ridges. The country is half burnt and partly grown up with black spruce, banksian pine, aspen poplar and white birch. Where unburnt the same trees are found, along with birch and balsam spruce.

"From Mistassini the eight men, with their canoes, returned to Lake St. John, and in consequence we had to depend on the natives of Mistassini to aid us in transporting our provisions. Two old men and a boy were found willing to go some distance with us, but on trial one man and the boy were found too feeble to carry, on the portages, and were soon discharged. The other old man had many years before made a trip to Nichicoon and he was taken along as guide.

Mistassini to East Main River.

"At Mistassini, a small rough sketch-map was procured, of the route up the East Main River to Nichicun, from Robt. Moore, a servant at Mistassini and formerly employed at Nichicun. This map was our only guide for some two hundred and fifty miles, as the 'guide' had forgotten the route and proved utterly useless.

"Lake Mistassini was left 5th July and, as in 1892, the North Branch of the Rupert River was descended some fifty miles, and then a portage route of fifty miles through chains of small lakes was followed to the East Main River. This stream was then ascended to the place where the survey of the previous year terminated, reaching there 15th July.

Upper East Main River

"From this point the micrometer survey was continued up the East Main River, one hundred and four miles, to where the route to Nichicun leaves the main stream to follow a small branch flowing in from the north-eastward. The general course of the river for this distance is slightly north of east. The river is very rough and rapid, with sixteen portages past chutes and rapids, besides a number of places where lightened canoes were tracked up. The valley of the river is shallow, and often the stream flows almost on the level of the surrounding country, widening into a number of lake expansions along its upper parts. The average breadth is four hundred yards, and it is often quite shallow. Two large branches come in on the south side, and one on the north side, together with a number of smaller ones. Along the lower part of the river, the country on both sides is quite low, with rounded hills running east and west. Thirty miles above the commencement of the survey, the country becomes higher, and to the sixteenth mile the river follows a valley between rough syenite hills that rise from two

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CANADA.

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Compiled by D. I. V. Eaton, C.E.

to five hundred feet above its level. Beyond that point the hills become lower and the valleys wider, and they are occupied by sharp ridges of sandy till, seldom over one hundred feet high. Above where the route leaves the main river, the country continues comparatively flat in the directions of the base of the mountains some thirty miles distant.

Labrador Peninsula—*Cont.*

" The trees along the East Main River are generally small, and only at favourable places along the bottom lands, do larch and spruce grow to eighteen inches in diameter at the base, where the country is unburnt. The highest hills are all wooded to their summits. Black spruce is the most abundant tree, being found everywhere, after which, in order of importance are larch, banksian pine, balsam spruce and white birch, the last being very small and not plentiful.

" The rocks along the river are composed of various gneisses and schists, together with syenites.

East Main to Big River.

" The branch by which the Nichicun route leaves the East Main River is quite small. It was followed for thirty-two miles, where a two-mile portage leads through a number of small lakes into a larger one that empties by another branch of the river. Following this lake five miles, to its head, a short stretch of river leads to another large lake from which a portage was made into a chain of small lakes, discharging by still another branch, and so on into Kawachagamak Lake, which may be taken as the source of the East Main River. This lake is about ten miles long and has numerous deep bays running off on both sides. From its head, a half-mile portage leads to a small lake from which the height of land, separating the waters of the East Main and Big Rivers is crossed.

" The general direction of the route from the East Main River to the height of land, is nearly north-east, and the distance, roughly, seventy miles. The country is generally low, with ridges of rock and drift running east and west, with a few hills rising three hundred feet above the general level. The trees are smaller and more stunted than along the river and over ninety per cent is black spruce, the remainder being larch with an occasional small clump of white birch. Much of the country has been burnt over, and the time required for a second growth appears to be very long.

" From the watershed, a small lake was passed through, and then another, five miles long, with a portage at its outlet, where it discharges into the Big River. The river below this point alternates between lake expansions, and narrows where it has a swift current and is about two hundred feet wide, It comes from the the southward, where it rises in a number of lakes on the northern slopes of the mountains about sixty miles distant. Having descended the river ten miles, we

Labrador Peninsula—*Cont.*

then passed through a large body of water called Back Lake, a short rapid was descended and the Hudson's Bay Post on Lake Nichicun was reached 4th August. Here we were hospitably received by Mr. J. Iserhoff, and through his kindness obtained much valuable information about the surrounding country, and also a guide to Lake Kaniapiscow, on the Koksoak or Ungava River.

Nichicun.

"Lake Nichicun is about thirty miles long and in its widest part over five miles across, with a number of deep bays. It is surrounded by rocky hills, from three hundred to six hundred feet high.

"Lake Nichicun was left on the 7th August, by following the middle one of its three discharges, in a northward direction, some twenty-five miles. Then, turning more eastward, the route ascended a small branch for thirty-five miles, passing through a chain of lakes on this stream. Thence a narrow height of land was crossed, and a small stream connecting two small, and one large lake, was descended to Lake Kaniapiskau. The country between Nichicun and Kaniapiskau is higher and more rocky than any previously passed through. The tops of the higher hills are barren, and the trees in the valleys consist of small black spruce, larch and a few scattered white birch. The rocks are almost wholly syenite with few exposures of bedded gneiss

Lake Kaniapiskau.

"Lake Kaniapiskau was entered at its north end, opposite its discharge. It is said to be over forty miles long, with a narrow part near its middle. Here our guides left us, and shortly afterwards we had the misfortune to upset one of the canoes in a rapid, and lost all of its contents that would not float. For fifty miles below Lake Kaniapiskau the river flows north-west, running nearly on the level of the surrounding country, in a succession of lake expansions connected by short rapids.

Begin descent of Koksoak or Ungava River.

"The surrounding country is low and comparatively flat, with low rounded ridges at intervals. Towards the lower end of this part of its course, the river begins to fall quickly in heavy rapids and small chutes. Turning abruptly to the east, it then enters a narrow valley, with rocky walls increasing in height from two hundred to five hundred feet as the river descends ten miles of heavy rapids, where its breadth varies from one to two hundred yards. For twenty miles below, there is a succession of rapids, and the stream widens to nearly half a mile and is very shallow. The hills on both sides continue high, with barren tops, and are covered with small black spruce on their sides. Veering again to the northward, the river continues with the same character for over fifty miles, while the surrounding country gradually lowers until the river is only slightly below its level. A large branch called Sandy River, from the south-east is passed, and then the river

again contracts as it falls over a number of ledges of syenite and passes through a low gorge fifty yards wide and a quarter of a mile long. Two miles below, it again contracts and passes into a crooked cañon about three hundred feet deep and one hundred feet wide. Here, in a mile, the river falls nearly three hundred and fifty feet, after which it is two hundred feet below the general level of the country.

Labrador Peninsula—*Cont.*

"Below these falls the river is narrow and rapid for five miles, but gradually widens to nearly half a mile and again becomes a succession of rapids with smooth stretches between.

Fall of eighty feet.

"Passing a fall of eighty feet, the river again contracts to about one hundred yards, and runs for nearly twenty miles with a strong current in a narrow crooked valley, with often perpendicular rocky walls rising over a thousand feet above it. After issuing from this valley, the stream widens out and becomes shallow, and soon enters Cambrian Lake, over twenty-five miles long and from two to five miles wide, surrounded by sharp rugged mountains. At the upper end of the lake, a large branch, called Death River, flows in from the westward, and Ice-dam River, from the same direction, enters about five miles below the lake. The rocks are all Laurentian, to about four miles below the upper branch, where these rocks pass under, and are partly covered by an unconformable series of sandstones, slates, shales and limestones. The overlying formation is highly charged with iron, and thick beds of hæmatite ore are met with in a number of places along the river lower down, where this series of rocks is passed through for a hundred and twenty miles. Millions of tons of iron ore must be in sight along the river, while still greater quantities of it, form sharp mountain masses on both sides.

Cambrian rocks.

Iron ore.

Lower part of river.

"Five miles below the Ice-dam River, there is a chute of sixty feet, with a large branch, named Swampy-bay River coming in from the eastward six miles below it, or about one hundred and twenty miles above Fort Chimo. Below, the river runs nearly north for seventy miles to where it is joined by the Still-water River, a very large branch from the westward. Between the Swampy-bay and Still-water rivers, the river flows in a wide valley, bounded by sharp hills and varies in width from a quarter of a mile to two miles, the average being about half a mile. Four miles above the Swampy-bay River it passes through a narrow gorge two miles and a half long. The only other obstructions between the forks, are two falls of sixty and eighty feet.

"Below the Still-water River the Koksoak widens to over a mile, has a swift current and is very shallow with numerous bars. There are wide intervals of low land between the river and the hills on either side.

Labrador Peninsula—*Cont.*

These hills run in sharp ridges from north to south and slope gently towards the east, while they present perpendicular faces on the opposite side.

"The bedded series of limestones and shales gives place to Laurentian gneisses about twenty miles below the Still-water River, and Laurentian rocks are seen at intervals along the river thence to its mouth. On entering the Laurentian area, the hills gradually fall and retreat, leaving a wide flat valley. The river here varies from two to five miles in width and has many large flat islands of drift, to within five miles of Fort Chimo, where the rocky hills again close in, and the stream is obstructed by a number of high rocky islands that extend to within two miles of the post. The banks continue high and rocky to the mouth of the river, some twenty miles below the fort. The largest trees found along the Koksoak River, grow along the shores of Cambrian Lake, where white spruce eighteen inches in diameter is not uncommon. Balsam poplar is also seen along that part of the river, together with black spruce, larch and white birch, all much larger than along the upper part of the river. Beyond the valley, on the sides of the hills, the timber is small and stunted, and the summits are bare. Below the Still-water River the trees again become small, and about Fort Chimo only stunted black spruce and larch are found, growing in protected valleys.

Reach Fort Chimo.

"Fort Chimo was reached on the 27th August, and our canoe trip of over twelve hundred miles across Labrador completed. Of this distance four hundred and fifty miles had been previously surveyed, leaving seven hundred and fifty miles for the season's work. By working hard, early and late, wet days and Sundays, Fort Chimo was reached at least twenty-five days sooner than it would have been under ordinary conditions of canoe travel.

Famine among the Natives.

"At Fort Chimo we were kindly received by Mr. Duncan Mathewson, and soon learned that a great famine had prevailed during the past winter among the Indians trading at this post, whereby nearly two-thirds of them, or upwards of one hundred and sixty persons died of starvation. This calamity was due to the failure of the reindeer to follow their accustomed routes of migration during the preceding autumn, when they did not cross the Koksoak River in great bands as usual. In consequence, the Indians who depend upon the reindeer for both food and clothing, were soon reduced to starvation, and being unable to obtain other supplies, died off by families during the winter. About twenty-five Eskimo also perished from the same cause. The surviving Indians having been in a state of constant starvation throughout the past year, and consequently being unable to trap furs and so pay their debts, were at the time of our visit in an abject state

of poverty. A collection was taken up among the white people here and the officers of the steamer 'Eric,' and sufficient was obtained to partly clothe the naked children and widows whose husbands had died the last year.

Labrador Peninsula—*Cont.*

"On hearing of the distress among the Indians, the Indian Department placed a sum of money at the disposal of the Hudson's Bay Company this year, and a recurrence of such a disaster will be impossible in future.

"The supply of pork at the Hudson's Bay post was too small to provide sufficient for the party if they remained at Fort Chimo, and as the risk of leaving provisions unprotected up the river, among starving Indians would be very great, it was deemed advisable not to winter at Fort Chimo, as originally intended; especially when it was learned that the work in hand could be carried on more advantageously from the head of Hamilton Inlet.

Voyage to Hamilton Inlet.

"Passages having been secured in the Hudson Bay Company's steamer 'Eric,' Fort Chimo was left on the 10th September for Rigolet, on Hamilton Inlet. On the way the Hudson's Bay posts at George River, Nachvak and Davis Inlet were visited, and such observations on the geology were made at each, as circumstances permitted. Rigolet was reached on the 1st October, and arrangements were made with Mr. J. A. Wilson for the transfer of provisions and outfit to Northwest River post, near the head of Hamilton Inlet, where we proposed wintering in the company's buildings, made available for that purpose by Mr. Wilson, who on this and later occasions materially assisted us in every way in his power. Provisions and outfit having been forwarded in a small schooner, the party proceeded in canoes to Northwest River post, following the north shore of the inlet.

Provisions sent inland.

"From here immediate preparations were made for despatching the men inland with the canoes. They left on 23rd October, and succeeded in ascending the Hamilton River one hundred and twenty miles before they were stopped by ice, where they remained until the river was wholly frozen up, and then returned to Northwest River, arriving there on 29th December. Mr. Eaton and myself remained at the Hudson's Bay post, where Mr. Cotter kindly shared his house with us and did everything in his power to make our winter pleasant and comfortable.

"During November and December, we were employed writing up the notes of the previous season, plotting the surveys and developing photographs. I left Northwest River for Rigolet on the 21st December with a dog-team, to secure men to aid in hauling provisions inland, and returned with eight men on the 17th January. Four men

Labrador Peninsula—*Cont.*

were engaged at Northwest River, and these with our own men, left on the 19th in charge of Mr. Eaton, each man hauling two hundred pounds of provisions along with the necessary extra clothing and outfit.

"This party succeeded in reaching the foot of the Gull Island Rapids, where they were obliged to câche their loads and return, owing to the rough ice in the rapids and the impassable country on both sides. During their absence I accompanied Mr. Wilson to Rigolet and from there to Sandwich Bay, in order to obtain as much information as possible of the country along the route.

Start for the interior.

"I returned to Northwest River on the 12th February, and remained there until the end of the month awaiting a sufficient fall of snow to render the rough ice passable. On the 29th, Mr. Eaton with two men left in advance, to carry on the micrometer survey, and on the 6th March the main party of thirteen men left for the interior.

"The câche where the loads previously taken in had been stored, was reached on the 10th, where four of the extra men turned back, being unable to stand the hard work. Continuing on with increased loads, some twenty miles of very rough ice was passed, and without further difficulties Muni Rapids, about ten miles below Lake Winokapau was reached. Here the river was found open and impossible to pass with loaded sleighs. A câche was made here, and the combined party returned to the first câche for the remainder of the provisions. Everything, including the canoes, was brought to the foot of the open water, where the canoes were loaded and then tracked or poled up to Lake Winokapau—very hard and disagreeable work with the thermometer below zero, and large quantities of anchor ice running down stream.

"The extra men were sent back from Lake Winokapau on the 1st April. From here everything had to be moved by our small party of six men, necessitating at first four and later three loads, and thus the same ground was traversed from five to seven times. As a consequence, the onward progress was very slow, and the Big Hill portage, one hundred miles above Lake Winokapau, was not reached until the 28th.

Character of Hamilton River.

"The Hamilton River flows in at the south-east corner of Goose Bay at the head of Hamilton Inlet. From its mouth to the Minipi River, one hundred miles above, the course is about west-south-west. At its mouth the river is nearly three-quarters of a mile wide, but soon it widens out, and averages a mile in width as far as the Muskrat Fall, twenty-eight miles above. Along this stretch, the river is very swift and shallow at ordinary stages of the water, and has scarped banks, that increase gradually in height as the stream is ascended, and are cut

out of sands that floor a wide valley between the rocky hills on either side.

Labrador Peninsula—*Cont.*

"The valley is well wooded with white, black and balsam spruce, larch, balsam poplar and white birch, much of the timber being sufficiently large to be cut for commercial purposes. The Muskrat Fall, or more correctly 'chute,' is about five hundred yards long, and the drop is seventy feet. From here to the Gull Rapids, thirty-two miles, the character of the river remains the same as below, and it varies in width from one-third of a mile to a mile. The sandy banks are often high and well terraced.

"At the Gull Rapids the hills approach, and narrow the valley to less than a quarter of a mile, while the rocky walls rise directly from the water to heights varying from three hundred to nine hundred feet above it.

"To the mouth of the Minipi River, a branch from the southward, the valley continues deep and narrow with the river rushing through it in a deep channel.

"From the Minipi River, the general course of the main stream to the Grand Falls is about north-west. A short distance above the Minipi River, the valley gradually widens out, and five miles higher up, it becomes again from one to two miles broad, between the hills. The river now averages half a mile in width for over twenty miles, when it again contracts to less than a quarter of a mile, and continues for twenty miles in a sharply defined rocky valley to the outlet of Lake Winokapau. The upper ten miles is a constant succession of heavy rapids.

Lake Winokapau.

"Lake Winokapau is forty miles long and averages one mile and a half in breadth, it is simply a portion of the ancient river-valley, which from some unknown cause has not been partly filled by glacial drift. The waters are deep to the base of the high rocky cliffs that bound the valley on both sides. Soundings made in the centre gave four hundred and sixteen feet, and within fifty feet of the shore a depth of eighty feet was obtained. Towards its upper end the sand brought down by the river has greatly decreased the depth, and a number of low islands and shoals obstruct navigation.

"Above the head of the lake, the river continues to flow in a slightly narrower valley, partly filled with drift; and except at a few short rapids, is easily navigable to the Big-hill portage, fifty miles above the lake.

"Extensive fires, during recent summers, have burnt almost the whole of the timber in the valley and on the surrounding table-land, from the Gull Rapids to beyond the Grand Falls. The small patches

Labrador Peninsula—*Cont.*

remaining show that the trees in the valley were of fair size, while the table-land is covered only with small black spruce and larch.

"Leaving the greater part of the supplies at the Big-hill portage, we followed up the valley some fifteen miles, to where the river enters it by a deep narrow cañon, coming into the main valley at a right angle on its north side. The main valley was seen continuing north-westward some twenty miles beyond this point. Above the portage the valley varies from a quarter of a mile to a mile in width, and as the grade is heavy, the river rushes through it as an almost continuous heavy rapid, which does not freeze over. Only a narrow margin of ice was found along the shore, and over it travel was slow and difficult.

"Where the main stream issues from the cañon, it is not over one hundred feet wide, and there was no ice along the foot of the perpendicular cliffs that rise seven hundred feet above the foaming water. In consequence, progress up the gorge was impossible, and a climb of seven hundred feet was made out of the valley on to the table-land above. Travelling overland, some five miles in a straight line, the place where the river precipitates itself off the general level was reached on the 3rd May.

The Grand Falls.

"Here the river was found to leave a small lake expansion, and narrowing to less than two hundred yards in width, falls two hundred feet in less than four miles rushing along in a continuous heavy rapid. In the last quarter of a mile, it narrows to less than one hundred yards as it sweeps downwards with huge waves over a number of rocky ledges preparatory to its plunge of three hundred feet, as the Grand Falls, into a circular basin about two hundred yards wide at the head of the cañon below. From this basin it passes out by a channel less than fifty feet wide, at right angles to the falls, and thus pent up in this narrow channel it rushes on in a zigzag course from five to seven hundred feet below the general level until it issues into the main valley below. The distance in a straight line from the falls to the mouth of the cañon is not much over five miles, but owing to the crooked nature of the cañon the river, with a fall of over three hundred feet, probably flows more than twice that distance before it reaches the main valley.

"After examining the falls and photographing them from above and below, the course of the river was followed to the small lake above, and from there the portage route was traced back through a number of small lakes to the Big-hill portage, at the foot of which the extra loads had been left. From the river, the portage rises abruptly seven hundred feet in less than a quarter of a mile. Three

days were occupied in carrying the provisions and outfit up the hill through snow and slush, after which everything was advanced by short stages until the 19th May, when owing to the rotten state of the ice in the small lakes sleigh work had to be abandoned, and a camp was formed, where everything was put in order for the summer canoe work.

Labrador Peninsula—*Cont.*

"The small lakes of the portage route being sufficiently clear of ice, camp was broken on the 30th and the main river reached next day. The river was found, however, to have only partly opened and to be full of large masses of floating ice over four feet thick, with the water between these, covered with slush holding long needle-like crystals of ice. The ice continued to pass down the river from the lakes above for ten days, not only greatly retarding the progress of our canoes, but also proving a source of considerable danger to them.

Opening of navigation.

"We were now fortunate in securing an Indian, as guide, who was acquainted with the routes to Lake Michikamau and to Mingan. He remained with us during the rest of the season and proved very useful.

"On account of the large supply of provisions, double loads were made to Sandgirt Lake, fifty-seven miles above the spring camp, where we arrived on the 15th June. This lake is very conveniently situated as a base from which to explore the surrounding country, the two main branches of the river flow into it, and the route to Lake Michikamau also passes through it. A câche to contain the extra provisions and outfit was here made on an island, and everything not immediately required was stored in it.

Depôt at Sandgirt Lake.

"Above the Grand Falls, the character of the river changes completely, and instead of flowing steadily in a deep well defined valley, it here runs almost on a level with the surrounding country, without any valley proper, but spread out into lake expansions and numerous channels separated by large islands, so as to occupy all the lower lands of a wide tract of country through which it flows. From the Falls to Sandgirt Lake, the general course continues about north-west, or parallel to the general trend of the low ridges that cross the country in that direction. The country surrounding the river is rolling, with rounded hills seldom rising more than three hundred feet above the general surface. Between the hills are wide valleys occupied by lakes or swampy land. The trees are small and black spruce predominates, with larch, balsam and white spruce and a few white birch.

River above Grand Falls.

"The first lake expansion above the falls is about six miles long, with the river flowing in at its head by a number of channels from the second or Flour Lake, some nine miles above. This lake is over ten miles long and is full of islands ; at its head the river again splits into

Labrador Peninsula—*Cont.*

a number of channels, the most southern of which was followed to Sandy Lake, where the river has three outlets.

Ashuanipi Branch.

"It was decided to first explore the west or Ashuanipi Branch of the river, and with a month's supply of provisions, Sandy Lake was left on the 18th June. As our guide had never traversed this part of the country, we experienced considerable trouble in finding the main channel owing to the bewildering lakes and islands. The branch flows into Sandgirt Lake from the north-west, and for thirty-eight miles averages a quarter of a mile in width, as it flows along with a swift current, between low sandy banks. In two places it widens into small lake expansions, and is often divided by large islands. Birch Lake was then entered, and its south shore followed for nine miles to where part of the river flows in, the remainder of it enters a bay on the north side. The south channel was ascended some ten miles to another long lake expansion out of which both channels flow. This lake was followed fifteen miles to its north end, where a short narrows connects it with Lake Petitsikapau.

Maze of lakes.

"This is a large irregular body of water with numerous long narrow bays, where a week was spent looking for the river, before it was discovered that it had turned southward before entering the lake. Returning to the last lake, three large irregular lakes, connected by short rapids, were passed through, and in all one hundred and twenty miles of survey was made while looking for the river. From the upper lake the ascent of ten miles of rapids brought us into a long straight lake to the south-west, lying nearly north-and-south, and varying from one to three miles in width. This was followed southward thirty-five miles, and then the crooked, rapidly flowing river was ascended in the same direction fifty-five miles, when owing to failure of provisions it was found advisable to stop work and return to the câche on Sandgirt Lake, where we arrived on the 17th July.

Cambrian rocks.

"From the mouth of the Hamilton River to within a short distance below Birch Lake, the route passes over a great area of Laurentian gneiss, along with syenite and intrusive basic rocks. There are followed at Birch Lake by an extension of the iron-bearing or Cambrian rocks met with the previous season along the Ungava River, and from there almost to the end of the survey on this branch these rocks are met with.

"On entering the Cambrian area, the physical aspect of the country changes. Sharp, parallel ridges running north-north-west, and rising from three hundred to six hundred feet above the general level, are seen in all directions, with wide valleys between them occupied by long narrow lakes and bays or channels of the river.

There is also a marked improvement in the size of the trees, due to a richer soil covering this area; and along the river and in the valleys, white, black and balsam spruce are frequently met with over twenty four inches in diameter three feet from the ground. White birch also grows larger and more abundantly than elsewhere. Unfortunately these large trees do not grow high, but branch out close to the ground, so that timber made from them would be full of large knots, and probably of little value.

Labrador Peninsula—*Cont.*

"The summits and northern slopes of the higher hills are barren showing the rigorous conditions of climate. Iron ores similar to those of the Ungava River are frequently met with in abundance.

Route to Lake Michikamau.

"An exploration of the country northward to Lake Michikamau was next made. The route from the câche passes northward to the end of Sandgirt Lake, where a channel of the river was descended into a large lake, which was crossed. Thence, three other large lakes full of rocky islands, and connected by a small branch, were passed through to a low height of land, with a mile portage, separating the Hamilton from the Northwest River. At high water there is an overflow from Lake Michikamau at this place, thus giving an outlet to that great lake by the Hamilton as well as the Northwest River.

"From the portage, the route leads through another long island-covered lake, and by a short stretch of river into a bay of Michikamau, which indents the main body of the lake on its southwest side near the middle of its length. From Sandgirt Lake to this place the general course is slightly east by north; the distance to the mouth of the bay being sixty-eight miles.

Size of the lake.

"Lake Michikamau is the largest body of fresh water in eastern Labrador, and is second only to Lake Mistassini, if it does not surpass that lake in area. The main body of the lake is fifty-five miles long from south-east to north-west, and in its widest part exceeds twenty miles across. There are few islands except along its southern and western shores, the water being remarkably clear and deep.

At the south-east end, are two long, narrow bays, which we were unable to explore, and along the south-west side there are a number of others, also unexplored. The Northwest River flows out on the north side, about twenty-five miles from the south end. The shores are often rocky and the lake is surrounded by barren rocky hills from two hundred to seven hundred feet in height.

"As the route is followed from Sandgirt Lake, the trees become very small and stunted, and about Lake Michikamau grow only on the lower lands and in protected valleys, leaving the hills and uplands bare.

Labrador Peninsula—*Cont.*—

"An outlier of Cambrian rocks, represented by lower beds of conglomerate and sandstones, occupies the body of the lake, and it is surrounded by hills of syenite and gabbro, the latter often in the form of large masses of precious labradorite. The country between Sandgirt Lake and Michikamau is wholly underlain by Archæan gneisses cut by masses of syenite and diorite or gabbro.

Attikonak Branch.

"Having made a circuit of the lake, the route was retraced southward to Sandgirt Lake, where the party again arrived on the 30th July. Two days later the câche was finally left, and the party started southward by the east or Attikonak Branch of the Hamilton River, which flows into the south part of Sandgirt Lake. This stream was ascended twenty-five miles to Osokmanuan Lake, which is about fifty-five miles long, but does not average more than four miles in width. Its surface is broken by many islands, a number of them being large. There is a second outlet on the east side not far from the south end, where a large stream flows out and finally joins the main river in the valley at the foot of the cañon. Ascending a stretch of five miles of river, a lake five miles long was passed through, and again the river was ascended about twenty-five miles to Lake Attikonak at its head. This is another large irregular body of water, with deep bays and dotted with innumerable islands. Its eastern shore was closely followed for forty-five miles, to the head of the south-east bay, where a small stream connecting two small narrow lakes, was ascended a few miles to the watershed between the Hamilton and Romaine Rivers. Crossing this, the Romaine River was soon reached, and its descent commenced. The country from Sandgirt Lake to the height of land is generally low, and broken only by occasional ridges of low rounded hills; much of the land is swampy and the timber small.

Height of land.

Romaine River.

"Where we reached the Romaine River, it is about one hundred feet wide, flowing between low banks for nine miles to the Burnt Lakes. The upper and largest of these is twenty-four miles long; it is separated from the middle lake by a short, heavy rapid. This lake is two miles and a half long, with one mile of rapid between it and the lower lake, which is ten miles long. These lakes are surrounded by low hills totally burnt over.

"Leaving this lake by a heavy rapid, the river was followed southward sixty-eight miles, through a distinct wide valley. As the river descends it is augmented by a number of small branches and is about a quarter of a mile wide along the lower courses. The hills surrounding the valley increase gradually, and finally rise from four hundred to seven hundred feet above it, and are almost wholly burnt. The current is swift, but broken by three rapids where portages are necessary.

"The river was left by a small stream within one hundred miles of the coast, and following up this branch, a chain of lakes on it and small branches of St. John River, were passed through to the last-named river. This route is over seventy miles long and traverses a high range of hills. The Romaine River, below this point is said to be impassable and must be very rough indeed to induce the Indians to use the present portage route, which is the hardest and roughest in my experience. The St. John River flows in a valley from one to two miles wide, bounded by high hills. In this valley the river descends rapidly, as it winds from side to side, and only one portage was made, to its mouth, seventy-five miles below where we first entered it, we reached the mouth of the river on the 22nd August.

Labrador Peninsula—*Cont.*

St. John River.

"On the route from Sandgirt Lake to the Gulf of St. Lawrence, only Archæan rocks were met with. Several large areas of gabbro or anorthosite were found, notably along Osokmanuan and Attikonak Lakes, below the Burnt Lakes on the Romaine River, and forming the high hills along the portage route to the St. John River and along that stream to within a few miles of its mouth.

"Proceeding next day to Mingan, our guide was discharged, and Quebec reached via Gaspé. Here the remaining men were paid off and sent home to Lake St. John.

Reach Mingan.

"Mr. Eaton and myself reached Ottawa on 1st September. The total distance travelled by the party from Lake St. John to Mingan, was approximately 5,660 miles, as follows :—

Distance travelled.

	Miles.
By canoe, Lake St. John to Ungava	1,100
By steamer, Ungava to Rigolet	1,000
By canoe, Rigolet up Hamilton River	220
By dog sleigh, Northwest River, to and from Rigolet and Cartwright	500
On foot with sleighs, Northwest River to Grand Falls	1,000
By canoe, Hamilton, Romaine and St. John Rivers.	1,640

"Micrometer surveys of 1,099 miles, and track surveys of 940 miles were made as follows :—

Surveys accomplished.

	Miles.
Micrometer survey, Upper East Main River	104
Micrometer surveys, Hamilton, Romaine and St. John Rivers	995
Track-survey from East Main to Ungava	600
Track-survey, Sandgirt Lake to and around Michikamau Lake	269
Track-survey, Lower St. John River	72

Labrador Peninsula—*Cont.*

General results.

"As a result of this work, the courses of the East Main and Hamilton Rivers will be laid down on the map from actual survey, where previously the only information concerning them was obtained from Indian sketches. The course of the Ungava, or Koksoak River and the position and shape of Lake Michikamau are also ascertained; and a line of exploration has been carried from south to north through the interior of Labrador, while the line from east to west is broken only by a distance of less than one hundred miles in the middle, between the head-waters of the Hamilton and East Main Rivers.

"These explorations will give a good idea of the physical aspect and climate of the interior, about which very little was previously known by the public, and will correct the popular idea that the Labrador Peninsula is a waste, barren region totally unfit for habitation.

"From the notes and observations made, the distribution of the forest trees may be laid down on the map, together with the southern limits of the semi-barren and barren lands. A collection of one hundred and twenty species of flowering plants were brought home from the Upper Hamilton River. These are valuable an an index to the climate of the region; and as most of them grow in Northern Quebec, the climate of the interior differs slightly from portions of the country at present under cultivation.

"Collections of birds, birds' eggs, butterflies, and beetles were also made and prove to be of considerable scientific interest.

Great abundance of fish.

"All the lakes and rivers of the interior were found well stocked with fish, those of the eastern watershed especially so. During the summer of 1894, the party lived almost exclusively on fish caught in nets or with lines. The net was nightly set at random and never failed to give a supply in the morning. Lake trout, often of large size, brook trout up to seven pounds weight, large white-fish and pike, land-locked salmon and two kinds of sucker were all taken almost everywhere.

"Meteorological observations were regularly kept three times a day, as well as notes on the thickness of ice, amount of snowfall and other points bearing on climate.

Geological information obtained

"The most important geological information obtained is the discovery of a great and hitherto unknown area of Cambrian rocks, extending north-north-west from north latitude 53° to beyond the west side of Ungava Bay. These rocks are made up of a great thickness of conglomerates, sandstones, slates, shales and limestones, together with intrusive igneous rocks. Their chief economic value is due to the immense amount of bedded iron ore found along with them.

The ores are chiefly specular and red hæmatite, together with beds of siderite or carbonate of iron. Thick beds of fine ore associated with jasper, were met with in many places, on both the Ungava and Hamilton Rivers; and the amount seen runs up into millions of tons. Owing to their distance from the seaboard, these ores at present are of little value, but the time may come when they will add greatly to the wealth of the country.

Labrador Peninsula—*Cont.*

Iron ores.

"Frequent observations on the direction of the glacial striæ, show that the ice during the glacial period flowed off in all directions from a central area south of Lake Kaniapiskau and between the headwaters of the Hamilton and East Main Rivers. Along the upper part of the East Main River, the ice moved nearly due west, and it also flowed in that direction near Nichicun Lake. The striation is very indistinct and the evidence of motion of the ice-mass is not definite from here to Lake Kaniapiskau. This portion of the country is covered by immense quantities of subangular blocks and boulders of local rocks, often perched on the very summits of the rocky hills and not uncommonly found resting on other blocks beneath, in such a position that the least movement would displace them.

Glacial striation.

"Erratics are very rare, and everything points to but a slight amount of movement of ice in this vicinity. At Lake Kaniapiskau the direction of the striæ show the ice flow to have been towards N. 60° E. while down the Ungava River it was more nearly north, corresponding with the general slope of the country. In the valley of the Hamilton River, only the south side is glaciated, and the direction of the striæ follows that of the axis of the valley. On the table-land above the Grand Falls, the direction of the striæ is very persistent, being constant over hill and valley, with a general direction of south-east.

"Near Lake Petitsikapau, the direction quickly changes to N. 50° east, apparently due to a change in the general slope. About Lake Michikamau the general direction is nearly due east. Passing south-ward to the Romaine River, and along it, the direction of the ice move-ment varies from east-south-east to south-east. On the St. John River the striæ are irregular and mostly follow the valley.

"A marked feature of the interior is the sharp ridges of drift that lie parallel to the direction of the striæ. These ridges are chiefly composed of fine material, with well rounded small boulders, of which a large percentage are far travelled. Where cut by the streams these ridges sometimes show indistinct signs of stratification and may be called eskers. In detail their contour is most irregular, forming a perfect network of sharp ridges joining one another from all directions,

Ridges of drift.

Labrador Peninsula—*Cont.*

with the material lying at very high angles impossible to obtain under water. They greatly resemble moraines formed by the melting of drift-laden ice at rest, and are indiscriminately scattered over the country. Terraces were observed on the sides of hills along both branches of the Hamilton River. These terraces rise to over one hundred feet above the present water-level and are so placed that they could only be formed along the shore of a lake or lakes formed by ice barriers.

Terraces

"Almost continuous terraces were traced along the sides of the deep valleys of the Hamilton and Ungava Rivers from their mouths, for over 200 miles inland. The post-glacial elevation on the Atlantic coast of Labrador, as shown from terraces and raised beaches, was not over 200 feet at Hamilton Inlet, and gradually decreases northward.

"The depth of Lake Winokapau, 416 feet, would indicate that the elevation of the land in pre-glacial times was much greater than at present, and that the valley of the Hamilton River has since been filled up with glacial drift, out of which the river is again cutting a channel; but owing to the less elevated state of the land it will probably not again reach the depth that it had previous to the glacial period."

Cost of exploration, 1893-94, $5,857.95.

New Brunswick.

(With adjacent parts of Quebec and Nova Scotia.)

New Brunswick.

Mr. R. Chalmers spent the winter of 1893-94 in the preparation and completion of a report on the surface geology of those portions of eastern New Brunswick, north-western Nova Scotia and Prince Edward Island, embraced in the three quarter-sheets No. 2 S.E., No. 4 N.W. and No. 5 S.W. (New Brunswick series). Mr. Wilson, who assisted Mr. Chalmers, was engaged, during the same time, in compiling and arranging the data for the maps and in getting them ready for the engraver.

Work by Mr. Chalmers.

On the field work done during the past summer, Mr. Chalmers makes the following report :—

"According to instructions I left Ottawa on the 10th of July to continue investigations in the surface geology of New Brunswick. Owing to the lateness of the time of starting, the limited amount of exploration funds at my disposal, and to the want of an assistant, Mr. Wilson having been kept in the office all summer, my work was of a more or less cursory character, and consisted partly in a revision of certain portions of that of previous years, and partly in preliminary

investigations in the north-western part of the province. A number of points were re-examined in the region around the Bay of Fundy, both in New Brunswick and Nova Scotia, and several questions elucidated from the additional facts obtained. The work in progress during the two years previous, along the valley of the St. John and in north-western New Brunswick, was continued, and some new and interesting data collected, especially as regards the glaciation, the dispersion of boulders, the formation of river-terraces, etc. The great development of terraces in this valley affords excellent facilities for studying them, and for tracing their relation to the glacial deposits. In the investigation of these questions, certain problems respecting the source of the Pleistocene ice which occupied the district, and of the boulders strewn over it to the north of the main granite belts traversing the province, presented themselves for solution. These problems seemed to render it necessary to extend our inquiries somewhat beyond the limits of the region specially investigated. Accordingly, towards the close of the season a short time was devoted to an examination of the contiguous parts of the province of Quebec and of the State of Maine.

New Brunswick—*Cont.*

"The first two or three weeks after my arrival in New Brunswick, were spent collecting Pleistocene marine shells, etc., my intention being to catalogue, at a future day, if possible, the Post-Tertiary fossils of the Maritime provinces. The Leda clays and Saxicava sands of the New Brunswick coast, especially in the Baie des Chaleurs and Bay of Fundy districts were searched, and also the boulder-clay in several localities, and a considerable number of species obtained.

Pleistocene fossils.

"Early in August I proceeded to the upper St. John, and Lake Temiscouata, a region presenting very interesting features as regards its surface geology. Temiscouata Lake lies in a great valley of denudation, extending transversely across the Notre Dame Range. Its surface is only 467 feet above the sea (Geology of Canada, 1863) and its depth in the centre, at Mount Wissick, is upwards of 200 feet. Since the erosion of the valley orogenic displacements have occurred, and these together with glacial action have produced a catchment basin for the drainage of a considerable region here, resulting in the formation of this lake. From the great bend in the lake, the Pleistocene ice seems to have moved northward and southward.

Temiscouata.

"Temiscouata Lake has, however, been much larger at one time than now, indeed most of our lakes stood higher and occupied a much larger area in early post-glacial times. In regard to the body of water of which Lake Temiscouata then formed a part, evidence is accumulating tending to show that it not only occupied a large portion of the drainage-basin of the existing lake and of Madawaska River, but

New Brunswick—*Cont.*

also the St. John valley as far south as Grand Falls. It is possible however, that the sea invaded these valleys at the above mentioned date, from the St. Lawrence, for though no marine fossils have been found in the deposits, granite and gneiss boulders, which look as if they might be from the Laurentides, occur on the shores of Lake Temiscouata, and, moreover, the level of these valleys is very nearly as low as the marine terraces which skirt the St. Lawrence River.

Grand Falls of the St. John.

"At the Grand Falls of the St. John, some remarkable phenomena showing the action of river ice came under notice. As the ice which covers the river immediately above the 'falls' every winter melts away, it moves down in a body, sliding over the surfaces of the ledges along shore. No distinct grooves or striæ are made, but the surfaces are eroded, planed and stossed, and have the appearance of being heavily glaciated.

"The limestone ledges above the 'falls' contain pot-holes. Though quite numerous, these are not as large or deep as the pot-holes in the gorge below the 'falls.' As there has been no cutting down of the rocks here by a water fall, the banks consisting wholly of boulder-clay, the question of the origin of these pot-holes is an interesting one. Two explanations are suggested; either the border of the Pleistocene ice lay here for some time, and the waters from its melting, producing these pot-holes, or there was a water fall or series of rapids over the boulder-clay bank, referred to during the period of its erosion.

"Observations were made on the Grand Falls itself, and on the gorge below in regard to their origin and the cause of the diversion of the river, by which they were produced. It would seem that while the damming of the river-valley by glacial drift is the apparent cause, it is probable that there has also been a transverse dislocation of the limestone strata here, in the early Post-Tertiary period, as a primary cause.

Granite boulders.

"Distributed over that part of New Brunswick lying north-west of the granite hills which traverse it from the Baie des Chaleurs to the Maine boundary at the Cheputnecticook Lakes, are of granite boulders, gneiss, etc., which must have their source northward and westward beyond the limits of the province. Many of these resemble rocks along the International boundary between Maine and Quebec, but the precise locality of the parent rocks, and the manner of their distribution, have not yet been satisfactorily determined.

"On the 4th of September I went to Nova Scotia to re-examine some of the doubtful points in the surface geology of the western end of the Cobequids, and study some features of the glaciation and boulder dispersion along the North Mountain, Annapolis Valley, etc.

"The differential uplift of the post-glacial marine shore-line in the Cobequid Pass, through which the Springhill and Parrsboro' railway runs, was traced out and more carefully levelled, and found to be higher than the shore-lines on either side of the mountains. There is also a difference between the height of the post-glacial shore-lines along Northumberland Strait, and those bordering Minas Channel and Minas Basin. Nova Scotia.

"The glacial phenomena of the north-west coast of Nova Scotia, from Minas Basin to Yarmouth, was investigated in a cursory manner, and it was discovered that this part of the peninsula shed the Pleistocene ice, north-westward into the Bay of Fundy depression. The ice overrode North Mountain, carrying granite boulders from the South Mountain, and strewing them over the former, down to the shores of the bay. Heavy striation and stossing, showing the direction of the ice movement, were observed in a number of places. Another fact in this connection was noted, however, viz., the occurrence of Triassic trap boulders on the South Mountain derived from the North Mountain. The north-west brow of the South Mountain was examined in a cursory manner for striæ and stossing, but none were discovered showing distinct south-eastward ice movement. How then did the trap boulders referred to, reach their present situation? To answer this question it seems necessary to suppose (1) that the Triassic rocks were originally laid down upon the north-west flank of the South Mountain, and (2) that the existing valley (Annapolis, etc.) between the two mountains is one of subsequent erosion. On this view Digby Gut is part of the old valley of Bear River, cut down through the Triassic rocks during the period of erosion. The boulders of Triassic trap met with on the South Mountain may, therefore, be simply remnants of the original overlapping rocks, left there as denudation proceeded backward from that mountain, just as the Carboniferous sandstones which formerly transgressed upon the crystalline rocks on the north side of the Cobequids left boulders, etc., on the slope and summit of these mountains as they were denuded. Glacial phenomena of north-west coast.

"The courses of striæ referred to, while trending north-westward, or nearly at right angles to the coast, along the North Mountain as far west as St. Mary's Bay, seem to swerve more and more to the west and south as we approach the western end of the peninsula. At Yarmouth the ice closely followed the courses of the estuaries, and moved nearly due south. Vicinity of Yarmouth.

"The facts taken altogether demonstrate that Nova Scotia has been glaciated entirely by ice which gathered upon its own surface, and afford no evidence of a great ice sheet crossing the Bay of Fundy and overriding that peninsula.

New Brunswick and Maine.

"On the 22nd of September I went into Albert County, N.B., for a few days to re-investigate some critical points in the surface geology along Demoiselle Creek, etc., and on the 27th I proceeded to St. John and spent a day examining the boulder-clay bank at Negrotown Point, collecting some shells from the glacial deposits of that locality. From St. John I went to northern Maine and south-eastern Quebec, for the purpose of observing the relation between the surface geology in these places and that of north-western New Brunswick.

Courses of striæ.

"At Moosehead Lake, Me., the glacial striæ trend S. 25° E., S. 11° E., S. 9° E., S. 5° E. and S. 30° W.,* the last course being the latest. No boulders from the International boundary or Notre Dame Mountains were observed here.

"A terrace about sixty feet in height above the surface of Moosehead Lake, borders it, showing that at one time in its post-glacial history this lake stood that much higher than its present level.

"At Lowelltown, Me., just south of the boundary, heavy glaciation is exhibited on the slopes of the ridges there, many of which have been overrun by forest fires, leaving the rocks bare. The courses of the striæ are S. 65° E., S. 69° E., S. 73° E., S. 80° E. and S. 86° E., the principal sets being S. 73° E. and S. 80° E. This is at the head-waters of Moose River which flows into Moosehead Lake. Mountains and valleys trending nearly east and west, have here formed a gathering ground for the ice which flowed in the direction above indicated. The hillsides are all heavily stossed on the west. So far as I could observe, the ice did not come through the transverse gaps of the divide. The upper parts of the rivers all flow eastward, and it is not improbable that a portion of the ice which collected on the south-east side of the boundary, moved in the direction of the upper St. John, as ice from the north-west side seems also to have done. Granite boulders from local sources are quite abundant, and similar granite boulders were noted in the upper part of the St. John valley.

Quebec.

"On the north side of the boundary line, the character of the surface is entirely different, especially along the Canadian Pacific railway. Instead of glaciated ledges and bare hills, there is an immense sheet of superficial materials, mantling, and almost everywhere concealing, the rocks from view. The evidence of a northward movement of drift in the Lake Megantic district is, however, unquestionable. Only in one spot were striæ observed, and these were on a flat surface; but boulders derived from the granite area to the south are very abun-

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* All courses of striæ and bearings are referred to the true meridian, the variation of the compass being 15° to 16° W. in the Eastern Townships and at the International boundary, and 18° to 22° W. in the lower St. Lawrence valley.

dant. The descent from the boundary to Megantic Lake is quite rapid, being more than 500 feet along the Canadian Pacific railway in the intervening sixteen miles.

Quebec—

"At Scotstown, several sets of striæ were observed, the most distinct being N. 35° W., N. 45° W. and N. 63° W. A second set trends about S. 65° E. Other ice-movements have also left their record on the rocks here, stossed faces being presented to the west, east, etc. These divergent courses may be due to ice which accumulated here from the north and from the south, and sought outlet by the lowest levels.

Courses of striæ.

"At Cookshire, well marked striæ were noted, trending in several courses between S. 48° E. and S. 58° E., the stoss-side being clearly to the north-west.

"At Sherbrooke, striæ, with courses bearing S. 48° E., S. 52° E. and S. 54° E. were met with, the ice apparently following the valley of the St. Francis River up stream. It will be noticed that the striæ at Cookshire and Sherbrooke have the same bearing, and were doubtless produced by the same body of ice. This was land-ice which probably came from the Sutton Mountain range, the north-eastward extension of the Green Mountains.

"Along the Quebec Central railway, there is evidence of an ice flow off the whole Sutton Mountain range south-eastward. Whether or not this ice crossed the valley of the Chaudière River and the International boundary reaching the valley of the St. John River, etc., is a question that can only be decided by further investigation.

"A great post-glacial lacustrine area lies to the south-east of the Sutton Mountain range, in the valley along which the Quebec Central railway runs, and the lakes seen there now are merely remnants of a former large lake or series of lakes.

"Granite and other crystalline boulders become numerous along the Quebec Central railway east of Weedon; and as we reach that part of the valley of the Chaudière lying below the level of the marine terraces, many boulders occur which are undoubtedly Laurentian.

Granite boulders.

"Between St. Charles station, Intercolonial railway, and Pointe Lévis, striæ were found running S. 63° W., stoss-side to the north-east. Height 145 feet. Striation, indicating ice-movements in the same direction, has been met with at Montreal by Sir J. W. Dawson, and also along the south side of the St. Lawrence below Lévis, viz., at Rivière du Loup, Trois Pistoles, Bic, etc. These may for the present be attributed to the action of floating ice, as in the other instances just mentioned.

Pointe Lévis.

Quebec—*Cont.*

"Granite, gneiss and other boulders from the Laurentian region are here plentifully strewn over the surface of the great marine plain of Pleistocene age on the south side of the St. Lawrence.

Courses of striæ on Lower St. Lawrence.

"At St. Thomas, Q., striæ were seen on the west ends of a number of long ridges lying parallel to the St. Lawrence, trending N. 67° E., N. 62° E. and N. 72° E., which are due to land-ice. At St. Francis station, Intercolonial railway, similar ridges are glaciated on both the east and west ends, the result probably of land-ice moving eastwardly at one time, and of floating-ice moving westwardly, at a subsequent date.

"The foot-hills of the Notre Dame Mountains here present perpendicular, or very steep faces towards the St. Lawrence, in some places with a *talus* at the base; while the summits are glaciated by land-ice which flowed northward or north-eastward. Evidently no ice from the Laurentian Mountains impinged against these foot-hills. The streams also run down the hillsides in repeated cascades, and it would seem as if there must have been recent uplifts in these foot-hills.

"Going along the Temiscouata railway from Rivière du Loup, a well marked marine shore-line was observed at a height of 418 feet above mean tide level.

"At Trois Pistoles, Bic, Ste. Flavie, etc., additional observations were made respecting the glaciation. Numerous sets of striæ occur in these places ranging in direction from N. 5° E. to N. 40° W., the dominant courses being N. 2° E. and N. 30° W. Deep grooves are common. Other divergent striæ trend N. 58° W. and N. 74° W. All these have been produced by land-ice flowing from the Notre Dame Mountains into the estuary of the St. Lawrence. Another light, irregular set ranging from S. 70° W. to S. 85° W. is supposed to be due to floating ice-masses driven up stream. These striæ are the latest, in proof of which it may be stated that the boulder-clay resting upon the glaciated surfaces is charged with Laurentian boulders which seem to have produced them, borne thither by this ice-driftage. The whole is capped with Leda clay and Saxicava sand, containing shells.

"The evidence of Pleistocene ice having moved northward from the Notre Dame Mountains into the St. Lawrence valley as far west at least as Lévis, may now be considered conclusive.

Metis to Metapedia.

"The Intercolonial Railway route through the Notre Dame Mountains was followed from Metis to Metapedia, but no evidence of ice from the Laurentian region having crossed the watershed was found. At Metapedia Lake, striæ occur trending in the direction of the valley, about S. 60° E.

"The remainder of the season, viz., from the 11th till the 29th of October, was spent in York county and along the South-west Miramichi valley. New Brunswick.

"In regard to the agricultural character of the country examined it may be remarked that the north-western part of New Brunswick comprises some tracts of the best arable lands of the province. The valleys of the St. John River and its tributaries, the Meduxnakeag, Tobique, Madawaska, etc., contain strips of bottom land of greater or less width which form excellent soil. Between Grand Falls and Edmundston the bottom land obtains considerable width, and in this part of the St. John Valley there are many excellent farms. Not only are the meadow lands noteworthy in this respect, but the uplands of Carleton, Victoria and Madawaska counties are also of remarkable fertility,—a fact to which the rapidly increasing settlement of this section of the country bears witness. Since the opening up of north-western New Brunswick by the Canadian Pacific and Temiscouata railways, marked progress has taken place in its agricultural condition, as well as in other respects. Agricultural land.

"A good deal of attention was devoted to the forest growth of the province during the season, and, in addition to the usual notes on the size and species of trees, in the locality more particularly investigated in north-western New Brunswick, some general information was obtained concerning the rate of growth of the woods of commercial importance, and on their preservation and replenishment in depleted districts. An examination of the trees now growing upon the area overrun by the great Miramichi fire of 1825 was made. Several localities within the burnt area, where it was known no forest fires have occurred since that date, were selected, and the girths of all the trees measured just above the roots. The following figures give the maximum measurements of the girth of a great number of trees of each species and show their rate of growth on a given soil (Middle Carboniferous or Millstone grit) during the sixty-nine years which have elapsed since the date of the fire :— Rate of growth of timber.

Poplar *(Populus tremuloides)*	51 inches
White spruce *(Picea alba)*................	54 "
Black " *(Picea nigra)*	48 "
Fir *(Abies balsamea)*.	40 "
Red pine *(Pinus resinosa)*................	52 "
Paper birch *(Betula papyrifera)*...........	44 "
Sugar maple *(Acer saccharinum)*...........	35 "
Swamp maple *(Acer rubrum)*..............	24 "
Beech *(Fagus ferruginea)*	24 "
Hackmatack *(Larix Americana)*..........	31 "

New Brunswick—*Cont.*

"In addition to the above species there are a few rowan trees, ash, alders, willows, viburnums, etc., of small growth.

"Of the trees enumerated, the red pine and black spruce are by far the most abundant and grow in such dense clumps on the drier spots as to exclude every other tree. The hemlock, black and yellow birch, cedar and white pine have not grown again since the fire.

"On limestone areas overrun by the Miramichi fire, the white spruce, paper birch, beech, etc., have grown rather larger than upon the Millstone grit, the girths of these exceeding the above measurements from one to five inches. In districts, too, where the woods are comparatively thin, *i. e.*, less dense than where I measured them, the trees show a tendency to be thicker and shorter.

"The foregoing data give some idea of the length of time our timber trees take to grow to become of economic value, when the forests are once destroyed.

Growth of spruce timber.

"From information obtained from New Brunswick lumbermen, it appears that they usually re-cut the logs off their spruce timber limits every ten or twelve years. Under the existing Crown Lands Regulations, no spruce or pine trees are allowed to be cut which will not make a 'merchantable log' 18 feet in length and 10 inches in diameter at the small end. If, therefore, timber of this size, or larger, can be cut off the forest lands every ten years or so, it seems reasonable to assume that, with a proper enforcement of these regulations and the preservation of the forests from fires, they might be conserved, and a growth of trees of commercial value ensured for generations to come.

"No new minerals or materials of economic importance were met with during the past season. Those which occur in western and north-western New Brunswick were recorded in the Report of Progress of the Geological Survey for 1882-83-84, part GG, and in reports by Prof. Bailey and Mr. McInnes.

"In Ryan's brickyard at Fredericton a fossil fish about 18 inches in length was discovered during the past summer by Prof. L. W. Bailey. It is reported to have been embedded in stratified clay at a depth of twenty-seven feet below the surface of the ground. The specimen is now in the Museum of the University of New Brunswick."

The cost of the season's explorations was $473.64.

Nova Scotia.

Nova Scotia—Work by Mr. Fletcher.

Part of the winter after the 31st December, 1893, was spent by Mr. H. Fletcher in plotting his surveys, in revising plottings of surveys made by his assistants during the previous summer, and in cor-

recting proofs of Nos. 30 to 36 of the Nova Scotian series of maps; but the greater portion of his time was occupied in compiling the map, on a scale of one mile to an inch, from these surveys, from Church's county maps and from plans made in the Nova Scotian government departments of Crown Lands, Mines and by the Provincial Engineer. Nova Scotia—*Cont.*

He left Ottawa on June 4th, 1894, to resume field work in Nova Scotia, to examine the geology of the district west of that described in last Summary Report and to work out in greater detail the geological structure of certain portions already surveyed. Nearly all the geographical surveys were made by his field assistants, M. H. McLeod and T. S. McLean, who were employed for four months, and surveyed the Herbert, Meander, St. Croix, Avon, Halfway and Gaspereaux Rivers, the shore, and the roads between Windsor, Laurencetown and Port George.

Mr. Fletcher reports on the work done, as follows :—

"The new district comprises the western portion of Hants county, north of the gold-bearing rocks, also part of the counties of King's and Annapolis south of North Mountain and east of Inglisville, which is not yet, however, finished. It is mostly low, well cultivated and especially adapted to fruit growing. Ship-building and lumbering are carried on to a small extent, and within it are the important quarries of gypsum at Newport Station, Wentworth and Windsor and the iron mines at Torbrook and Nictaux. Districts surveyed.

"The geological formations recognized are Triassic, Carboniferous limestone, Devonian, Silurian, Lower Cambrian and igneous. Large deposits of drift, carried apparently both from the north and from the south, conceal in places the underlying rocks, making land which would otherwise have been barren, fertile; while rounded and striated rocks are found at many points, and clays used for making bricks at Avonport and elsewhere. Geological formations.

"Triassic sandstone and conglomerate occur on the shore west of Avonport. The greater part of the North Mountain is composed of trap and allied igneous rocks of this period.

"The Carboniferous limestone occupies the eastern part of the district. A characteristic section of its gypsum, limestone and marls, on the Avon River at Windsor, has been described by Sir J. W. Dawson (Acadian Geology, page 558) and these rocks are also seen on the road from Scotch Village to Woodville, on Herbert River above and below that road, and in many streams of the neighbourhood. On Walton River, not far below the confluence of Shields Brook, pits have been dug in a reddish, greenish and gray, mottled, impure and concretionary lime-

Nova Scotia—*Cont.*

stone, resembling the Tennycape manganiferous belt, containing small vuggs lined with dog-tooth spar, limonite and hæmatite. The greater part of the river is occupied by this formation. On a branch of the North-east Tennycape River, on the south side of the brook, at the contact of this 'mineralized zone' (as the lowest limestone, the horizon of the Tennycape Mine, and of other mineral deposits in Nova Scotia is called by Mr. Poole) with the Devonian, Captain Scott, Mr. Wright and others have sunk a shaft thirty feet deep, and obtained a small quantity of good pyrolusite. Gray and rusty, soft, thick-bedded sandstones, with a low northerly dip overlie the limestone and gypsum of Kennetcook River and the barrens north of it between Upper Kennetcook and Kennetcook (Burlington). These sandstones have been quarried for railway-bridges and other purposes, although said to be too soft and full of 'shakes' for grindstones; they are also seen in Cockmagun and Tomcod Rivers and resemble the coal-bearing strata of Stewiacke River. They contain plants of coal formation genera and a small seam of coal, (Acadian Geology, page 268; Summary Report for 1889, page 30), have the aspect of true coal-measures, and are commonly supposed to be productive. These may belong to the Millstone grit, but are quite distinct from the grit, sandstone and shales of Five-mile River (Summary Report for 1893, p. 41) and the Gore, which have also been prospected for coal, but underlie the limestone unconformably.

Beds below Carboniferous limestone.

"At some points the Carboniferous limestone rests directly upon the gold-bearing series, but at others these lower plant-bearing strata intervene. They are well exposed at Horton Bluff (Acadian Geology, page 253), and along the shores between Avonport and the mouth of Halfway River. Where they succeed quartzite and staurolite-schist in the brook from which Windsor is supplied with water, they consist of whitish-gray and rusty, fine and coarse quartzose grits, coherent or loose in texture, dipping N. 22°, W. $<$ 27°, interstratified with thick bands of blackish, shiny, bituminous shales, like those of Hallowell Grant and East Bay, Cape Breton, some of which will burn and have been mined for coal, while others, full of rootlets, constitute true under-clays. Overlying these beds are reddish and gray sandstone and coarse grits—the whole resembling the more southerly arenaceous rocks of Horton Bluff.

"West of Gaspereaux River, these rocks are apparently replaced by older strata. In the branch of this river from which water is taken for the town of Wolfville, gray shales and dark micaceous flags with impressions of fossil plants, are associated with whitish quartzose sandstones, containing 'bulls' of rusty-weathering, greenish, pyritous, cohe-

rent sandstone, and with red argillite, including cream-coloured and greenish layers, mottled with rusty and hæmatitic spots, and underlaid by steel gray and blackish nacreous slates of the auriferous series.

Nova Scotia—*Cont.*

"In the large branch of Kennetcook River, which comes in from the south at Riverside Corner, whitish, crumbly, coarse sandstone, gray flaggy sandstone and reddish and greenish, somewhat coherent marls, very like the Devonian of Five-mile River, are interstratified with blackish grit, containing broken carbonized matter and indistinct *Cordaites*. Fine exposures of Carboniferous limestone are, in the Herbert River, underlaid by a narrow belt of gray, fine, micaceous sandstone and whitish coarse granitic grit, which is itself underlaid immediately by the auriferous series, as described by Mr. Faribault.

Silurian rocks.

"Silurian rocks, holding marine fossils, are found in the hill country of New Canaan, Nictaux and Inglisville, associated with others perhaps older, and also with a series supposed by Sir J. W. Dawson to be Oriskany. Interstratified with the last is the hæmatite bed of Torbrook, six feet thick, (from which about 35,000 tons of iron ore are annually extracted for use in the furnaces at Londonderry and Ferrona), and the iron ores of Nictaux and Cleveland, not worked at present. A collection of fossils from these beds, made last smmer by Dr. A. H. McKay, of Halifax, Mr. John E. Leckie, of Torbrook, and myself, has been given to Dr. Ami for comparison with those found by Dr. Bailey at Nictaux (Summary Report for 1892, p. 57) and with others in the Survey museum.

Crystalline rocks.

"The most important masses of crystalline rocks are the granites and diorites of the South Mountain, of Silurian age or older, and the trap of North Mountain which is Triassic.

Devonian strata.

"Several weeks were also spent by me, assisted by Mr. M. H. McLeod, in a re-examination of the Devonian rocks of Riversdale and Lower Five Islands, at Calvary Stream, the Black, Salmon and North Rivers, Penny's Mountain, Union, the West, Middle and East Rivers of Pictou, Stewiacke River, Five Islands, South Maitland, Knoydart and the Strait of Canso, which has confirmed the conclusion arrived at after the first examination in 1884, in company with Dr. Ells, viz., that they underlie the red rocks of Union, which in turn lie unconformably beneath the Carboniferous limestone, as stated in previous reports,* and have been metamorphosed by the syenite and other plutonic rocks of the Cobequid Hills. It seems probable that the dioritic and felsitic schists of these hills as well as those of Moose River, and the Garden of Eden have originally been igneous rocks, which are elsewhere represented by massive forms.

*Annual Reports Geological Survey of Canada (N.S.) Vols. II., IV. and V.

Nova Scotia—Cont.

"Some investigations were also made of certain doubtful points in the geology of the country represented on the sheets of Antigonish and Pictou counties, now being engraved and in an unsuccessful search for fossils in the rocks there met with, which are believed to be of Cambro-Silurian age. Mr. McLean also spent a few days in the Pictou coal field to add to the topography of the large map of that district.

Iron mining.

"Work has been vigorously prosecuted by the Pictou Charcoal Iron Company, and by the New Glasgow Iron, Coal and Railway Company at their iron mines at Bridgeville, where explorations are being made to find ore at the contact between the Carboniferous limestone and Devonian on the opposite or left bank of the East River. By the latter company, mines were opened on the Trunk Road hæmatite bed and on those of Doctor's Brook in Antigonish county; while work done by the company on the Big Blanchard bed has shown that, instead of being from thirty to one hundred feet thick, as its superficial appearace would indicate, it is only four feet and a half thick, bent horizontally on a roll. The display of Nova Scotian minerals and products of the mines, now being prepared by Dr. Gilpin, inspector of mines, for the Imperial Institute, London, is to include iron ore, fluxes, fuels, and pig iron, made by this company at Ferrona, also rails, shafting, &c., made at Trenton by the Bessemer process from their iron.

Coal.

"The amalgamation of most of the collieries in the Sydney coal-field by the Dominion Coal Company, has stimulated prospecting, and valuable discoveries of coal have been reported. Recent work at the Richmond coal mines throws no new light on the relation of that coal to the gypsum and limestone. From a deposit of fine sand found near River Denys station, a paste or bathbrick has lately been manufactured in Pictou for use on the Intercolonial and Canadian Pacific railway. Associated with it is a quantity of excellent clay, said to be adapted for fire-bricks and tiles.

"Further examinations have been made of the strata overlying the coal measures in Pictou county. Two bore-holes were put down by the diamond drill in search of coal—one at Abercrombie, 350 feet deep, passed through gray sandstone; the other at Poplar Hill, 214 feet deep, through alternations of red shale, gray sandstone and coarse concretionary grit or limestone-conglomerate, the gray beds containing carbonized plants. At Sundridge, on the farm of Mr. Robert Macdonald, are pits, not before mentioned, on one of the deposits of copper ore so characteristic of this formation (Annual Report Geological Survey, Vol. V. (N.S.), Part P, p. 186). Chalcocite occurs in a gray and reddish flaggy sandstone, and still more abundantly in layers of concretionary limestone-conglomerate, like that of the Poplar Hill

bore-hole. It is mixed with carbonized plants, as in the case of similar deposits on French and Waugh Rivers and elsewhere. Before the land was cleared, the spot at which it has been opened is said to have been barren." Nova Scotia—*Cont.*

Cost of the season's explorations and surveys, $725.

Mr. E. R. Faribault reports on the work accomplished by him during the year as follows:— Work by Mr. Faribault.

"According to instructions received, all the time at my disposal during the past summer was devoted to the further mapping and study of the gold-bearing Cambrian rocks of the Atlantic coast of Nova Scotia.

"After the close of field operations of 1893, the winter months, from the 15th of December until the 1st of June, were chiefly occupied, as in the previous year, in compiling the map of the area previously surveyed. This work, included the plotting of the instrumental surveys made during the summer, the revising of plotting done by the assistants, the reduction of plans from the Admiralty charts, the Crown Land Department and other sources; the compilation and adjustment of these various surveys on the projection prepared by the late Mr. Scott Barlow on the scale of one mile to one inch, the laying down of the geological lines and other data gathered in the field; and finally, the study of the geology of the area laid down on the map and the making out of the structure of the numerous folds into which these gold-bearing rocks have been thrown; especial attention being paid to the study of the anticlinal axes and their intimate relation to the auriferous belts. Progress of the maps.

"A final decision having been arrived at to continue the publication of the Nova Scotia maps on the scale of one mile to one inch in the same style as those already published, a considerable amount of time was taken up in preparing the manuscript maps for sheets Nos. 27, 28, 29, 30, 36, 37 and 38, a few alterations in, and additions to, the topography and geology being also made from supplementary notes taken the previous summer, in order to bring the maps up to date. I also attended last winter to the correction of proofs of sheets Nos. 25, 26, 27, 28, 29 and 30, and last summer while in the field to the correction of proof of sheet No. 36.

"Transverse structural sections were also prepared for sheets Nos. 27, 28, 29, 30 and 37, to be engraved on the margin of each sheet.

"Since my return this fall, a section for sheet No. 38 has been prepared, and corrections of proof of sheet No. 37 made. Sheets Nos.

Nova Scotia—*Cont.*

36, 37 and 38 are still in the hands of the engravers. These sheets, together with those previously mentioned and those prepared by Mr. Hugh Fletcher, are the fourteen first sheets of Nova Scotia proper, excepting sheets Nos. 22 and 24, which were published with the Cape Breton series. The fourteen sheets are numbered from 25 to 38 inclusive, covering the eastern part of the province extending from Cape Canso westward to Beaver Harbour on the Atlantic and Barney's River on the Strait of Northumberland. The country covered by these sheets has been fully reported on by Mr. Fletcher and the writer, in the Annual Report for 1886 (Part P), with the exception, perhaps, of sheets Nos. 37 and 38, which still require some further detailed explanation.

Gold mining.

"Although drawn on the small scale of one mile to an inch, the above mentioned sections give a good idea of the general structure of the plications of the rocks, and will show to a certain degree the intimate relation of the quartz veins, auriferous or not, to the anticlinal saddle. It is believed that the future of deep and permanent gold mining in Nova Scotia, depends greatly on the proper understanding by miners of this mode of structural occurrence of the quartz veins. The system of deep mining employed in Australia and more especially in the Bendigo gold field, where the quartz reefs occur very much in the same manner, might be adopted with advantage in Nova Scotia. Most of the mining there is carried out by means of perpendicular shafts sunk along the anticlinal axis, with cross-cuts and levels, which cut and afford the means of working out the quartz in interbedded veins (most of which curve around the anticlinal saddle and do not outcrop at the surface) to depths ranging from a few feet to 2,850 feet in the famous Lansell's 180 mine. That system could be applied also, in most cases, to quartz mining in Beauce district, in the province of Quebec, where the rocks are exactly similar.

Districts examined in 1894.

"I left Ottawa on the 1st of June for Nova Scotia, to commence the season's field work, and returned to the office on the 15th of September. The greater part of the summer was spent, assisted by James McG. Cruickshank, re-examining the gold-bearing rocks of that part of the province comprised between the East River Sheet Harbour, Gay's River, Stewiacke River, and the Atlantic shore, in the counties of Halifax and Colchester. The anticlinal folds were followed along their course, and the structure of each one carefully studied wherever possible, in order to locate any elevation of the axis forming a dome, having the characteristic structure of a gold district. Several such domes were located, and their eastern or western dip will indicate the probable pitch of the pay streak of gold in the quartz veins. Numerous

faults of more or less magnitude, affecting the structure of these rocks, were also found. One of these, having over one mile of a thrust, has been traced thirty-two miles up the West River Sheet Harbour to the Carboniferous basin of the Musquodoboit River.

Nova Scotia—*Cont.*

Fire-clay.

"The boundaries of the Lower Carboniferous basins of the rivers of Musquodoboit, Stewiacke, St. Andrew's and Gay's have also been delineated. Some extensive deposits of fire-clay have been discovered in the valley of the Musquodoboit River. Specimens submitted to Mr. G. C. Hoffmann, the chemist of the Survey, were pronounced on a preliminary examination to consist of a mixed material. Mr. Hoffmann says of them: 'Although apparently uniform (by reason of the whole being more or less coated with ferric hydrate) I found that some of the fragments when freed from this were fairly whitish in colour, and when burnt remained so, while other pieces were of a uniform grayish colour throughout, and when burnt assumed a reddish-brown colour. A mixture of equal parts of the two kinds might be expected to burn pale reddish-brown, but possibly one or the other kind may predominate in the deposit.' For the purpose of ascertaining this, larger specimens were collected, and these will afford material for further and more satisfactory experiment.

Further work required.

"The field investigations and mapping of the topography and structural geology of the nine sheets Nos. 39, 40, 41, 42, 48, 49, 50, 51 and 52, have thus been brought to a close, and the preparation of these sheets for the engraver will be completed in the course of about two months. The four adjacent sheets, Nos. 53, 54, 55 and 56 require still some further study in the field of the structural geology. A detailed report to accompany the above thirteen sheets and part of sheets 37 and 38, all contained in the counties of Halifax and Colchester, has been commenced, and will be finished in the course of the winter. Most of the topography and part of the geology have been done for sheets Nos. 65, 66, 67, 68 and 73, in the counties of Hants and Halifax. The roads traversing the areas of sheets No. 69, 70, 71 and 72 have been surveyed by odometer.

"Mr. A. Cameron was engaged surveying with the odometer, and plotted 296 miles of roads in Lunenburg, 23 miles in Hants, 49 miles in King's, and 42 miles in Annapolis counties:—a total of 410 miles, to be used as tie-lines in next year's contemplated topographical work, most of which is included in sheets Nos. 85, 86, 87, 88, 96 and 97."

Cost of the explorations of the season, $715.16.

CHEMISTRY AND MINERALOGY.

Chemistry and mineralogy.

Reporting on the work of this division, Mr. Hoffmann says :—" The work carried out in the chemical laboratory during the past year has been, conformably with the practice of former years, almost exclusively confined to the examination and analysis of such minerals, ores, &c., as were considered likely to prove of economic value and importance. It embraced :—

Analyses made.

" 1. Analyses of coals and lignites.

" 2. Analyses of mineral and other waters from localities in the provinces of New Brunswick, Quebec, Ontario, Manitoba, North-west Territories and British Columbia.

" 3. Analyses of iron ores, from the provinces of Nova Scotia, New Brunswick and Quebec.

" 4. Analyses of numerous samples of pyrrhotite for nickel and cobalt.

" 5. Assays of a large number of ores for gold and silver from numerous localities in the provinces of Nova Scotia, New Brunswick, Quebec, Ontario, North-west Territories and British Columbia.

" 6. Miscellaneous examinations. These include the partial analysis or testing, as the case might be, of brick, and pottery clays, manganese ore, iron sands, barytes, chromic iron ore, graphite, carbonaceous shale, sandstone, marls, etc.

Mineral specimens examined.

" The number of mineral specimens received, during the period in question, for identification, examination, or analysis, amounted to six hundred and ninety-four. A large proportion of these were brought by visitors desirous of obtaining information in regard to their economic value, and this was in many instances communicated in the course of a personal interview. In other instances, those where a more than cursory examination was called for, or a partial or even complete analysis was deemed desirable, as also in the case of those specimens which had been sent from a distance—the results were communicated by letter. The number of letters personally written, chiefly in this connection, and generally of the nature of reports, amounted to one hundred and sixty-eight, and the number of those received to sixty-six.

Work by Messrs. Johnston and Wait.

" Messrs. R. A. A. Johnston and F. G. Wait, assistants in the laboratory, have both rendered excellent service. The former, in addition to the carrying out of a lengthy series of gold and silver assays, has made numerous analyses of important minerals, and also conducted a great variety of miscellaneous examinations, in all of which work he has displayed both ability and skill; whilst the latter has been engaged in the analysis of mineral and other waters, iron-ores, marls, the estima

tion of nickel in samples of pyrrhotite, and has also made some miscellaneous examinations. Chemistry and Mineralogy—*Cont.*

"The regular annual report 'Chemical Contributions to the Geology of Canada,' has been written, and is now in course of publication. In the work in connection with the mineralogical section of the museum, I have been diligently assisted by Mr. R. L. Broadbent. Apart from the general museum work, such as the labelling and cataloguing of all newly received specimens, and the maintaining of the collection generally in an orderly condition, he has numbered and prepared a manuscript catalogue of the now somewhat extensive collection of foreign minerals, *i.e.*, minerals from localities outside the Dominion, and also arranged and made a list of the contents of the drawers under the wing-cases. Museum.

"Fifty-two photographs, the greater number coloured, fourteen inches by ten, mounted and framed, representing views of mines and views illustrating structural geology, have been arranged over the central table-cases in this section of the museum.

"Many of the mineral specimens have been replaced by more characteristic ones, and the collection augmented by the addition of some one hundred and fifty others, as follows:— Contributions to museum.

"(A.) Collected by members of the staff, or others engaged in field work in connection with the Survey :

1. Adams, F. D. :—

Nephelite and sodalite, from York River, near side-line between lots 12 and 13, range XI. of the township of Dungannon, Hastings county, Ont.

2. Ami, Dr. H. M. :—

(*a*) Crystals of pyrite, from the township of Wakefield, Ottawa county, Que.

(*b*) Calcite, from Crystal cave, Mount Stephen, Rocky Mountains, B.C.

(*c*) Crystal of pyrite, from six miles north-east of Illecillewaet, West Kootanie district, B.C.

3. Bailey, Professor L. W :—

(*a*) Stilbite, sixteen specimens, from North Mountain, Annapolis county, N.S.

(*b*) Mesolite, twenty-four specimens, from Murphy's Cove, Digby Neck, and North Mountain, Annapolis county, N.S.

(*c*) Heulandite, one specimen from Digby Neck, and another from North Mountain, Annapolis county, N.S.

Contributions to museum—*Cont.*

(*d*) Quartz, seven specimens, from Johnson's and Nichol's mines. and Petite Passage, Digby county, N.S.

(*e*) Agate, twenty-six specimens, from Johnson's and Nichol's mines, Digby Neck, N.S.

(*f*) Martite, ten specimens, from Nichol's mine, Digby neck, N.S.

(*g*) Magnetite, five specimens from Mink Cove, Digby county, N.S.

(*h*) Hæmatite, a specimen from Torbrook, Annapolis county, N.S.

(*i*) Selenite, six specimens from Elmsdale, Hants county, and one from Blomidon, Kings county, N.S.

(*j*) Gypsum, fibrous, eight specimens from Blomidon, King's county, N.S.

(*k*) Siderite, one specimen from St. Mary's Bay, Digby county, N.S.

(*l*) Magnetite, from Nichol's mine, Digby Neck, Digby county, N.S.

4. Brumell, H. P. :—

(*a*) Crude petroleum, from Lyppswell, lot 8, range I. of Gosfield, Essex county, Ont.

(*b*) Chabazite, six specimens ; pyroxene, four specimens ; scapolite, one specimen ; titanite, three specimens ; biotite, three specimens—all from lots 24 and 25, range VI. of Monteagle, Hastings county, Ont.

(*c*) Apatite, from lot 26, range VI. of Monteagle, Hastings county, Ont.

(*d*) Molybdenite, from lots 26 and 27, range VI. of Monteagle, Hastings county, Ont.

(*e*) Apatite, from lot 22, range XIV. of Cardiff, Haliburton county, Ont.

(*f*) Apatite, from the township of Faraday, Hastings county, Ont.

(*g*) Sodalite, five specimens ; lepidomelane in sodalite, three specimens ; nephelite, one specimen—all from lot 25, range XIV. of Dungannon, Hastings county, Ont.

(*h*) Magnetite, from lot 25, range XIV. of Dungannon, Hastings county, Ont.

(*i*) Graphite, disseminated, from lot 28, range XIII. of Dungannon, Hastings, Ont.

(*j*) Muscovite, six specimens ; perthite, twelve specimens, from lot 20, range X. of Dungannon, Hastings county, Ont.

(k) Magnetite, from the west-half of lot 19, range I. of Belmont, Peterborough county, Ont. Contributions to museum—*Cont.*

(l) Lithographic stone, from lots 7 and 8, range III. of Marmora, Hastings county, Ont.

5. Dawson, Dr. G. M. :—

(a) Strontianite, from Horsefly River, Cariboo district, B.C.

(b) Stibnite (in a gaugue of dolomite and barite) from the Rosebush claim, near the mouth of Copper Creek, Kamloops lake, B.C.

(c) Leucite rocks, from the Horsefly River, Cariboo district, B.C.

(d) Sphærosidesite in basalt, Horsefly River, Cariboo district, B.C.

(e) Opal, common, Horsefly River, Cariboo district, B.C.

(f) Gold, native, from the Horsefly mine, Horsefly River, Cariboo district, B.C.

(g) Platinum, native, Horsefly River, Cariboo district, B.C.

(h) Copper, native, from the same locality as the preceding.

(i) Aragonite, Mussel Creek, Horsefly River, B.C.

(j) Barite, crystallized, in lignite, from Horsefly River, Cariboo district, B.C.

(k) Gold, native, from Quesnel River, B.C.

6. Faribault, E. R. :—

Clay, from McKenzie Brook, Middle Musquodoboit, Halifax County, N.S.

7. Ferrier, W. F. :—

Pearl-spar, a specimen of, from the corporation quarry, Outremont, near Montreal, Que.

8. Fletcher, H. :—

Clay iron-stone, from the Albion mines, Pictou county, N.S.

9. Giroux, N. J. :—

Infusorial earth, from Trompe Souris,, north of St. Justin village, Maskinongé county, Que.

10. Lambe, L. M. :—

Iron-sand, Cap à l'Aigle, Charlevoix county, Que.

11. Low, A. P. :—

(a) Magnetite, four specimens; magnetite with hæmatite and red jasper, magnetite in garnetiferous granite; magnetite with brown jasper; magnetite with ankerite; hæmatite and magnetite with red jasper—all from Ungava River, Labrador.

(b) Magnetite in quartz; hæmatite and magnetite, with red jasper; anthraxolite—from Hamilton River, Labrador.

Contributions to museum—*Cont.*

12. McConnell, R. G. :—

Pyrargyrite, from the Dardanelles claim, Kaslo-Slocan mining district, West Kootanie, B.C., and other specimens, which are under examination.

13. Prest, W. H. :—

Agate, and Banded jasper, from Johnson's mine, Digby Neck, Digby county, N.S.

14. Selwyn, Dr. A. R. C. :—

Limestone showing cone-in-cone structure from the north-east corner of the district of Athabasca, N.W.T.

The following were obtained by Dr. Selwyn for the Museum, at the World's Columbian Exposition, Chicago :—

(*a*) Silver ore, from the Broken Hill, New South Wales, Australia.

(*b*) Alunite and alum, from Bulladella, New South Wales, Australia.

(*c*) Rose garnet, from Xalostoc, Mexico.

(*d*) Magnesite, from Mantudi, Greece.

(*e*) Chalcopyrite with pyrrhotite, from the Atlantic mine, Deer Lodge county, Montana, U.S.A.

(*f*) Silver ore, from the Daly mine, Park city. Summit county, Utah, U.S.A.

15. Weston, T. C. :—

Nodular pyrite, from Point Lévis, Lévis county, Que.

16. Willimott, C. W. :—

See further on.

"(B.) Received as presentations :—

1. Cameron, Robert, Almonte, Ont., per J. F. Whiteaves :—
Limestone concretions, from Sault Ste. Marie, district of Algoma, Ont.

2. Constantine, Charles, Inspector North-west Mounted Police :—

(*a*) Coal from stream flowing into the Yukon River, east side, three miles above Forty-mile creek.

(*b*) Vivianite, Yukon river valley, about forty miles above Forty-mile creek.

(*c*) Copper, native, from near the head of Copper River, Alaska.

3. Fairbairn, David, North Wakefield, Ottawa county, Que. :—
Argentiferous galena, from the Ottawa and W,akefield claims Kaslo-Slocan mining district, West Kootanie, B.C.

4. Fournier, Xavier, Murray Bay, Que., per Dr. H. M. Ami :—
Muscovite (crystal), from Lac au Pied des Monts, Charlevoix county, Que.

Contributions to museum—*Cont.*

5. Hayden, Dr., Canmore, N.W.T. :—
Semi-anthracite, showing cone-in-cone structure, from Canmore, district of Alberta, N.W.T.

6. Jaques, Capt. Josiah, Victoria, Vancouver Island, B.C. :—
(*a*) Ilvaite, from Barclay Sound, Vancouver Island, B.C.
(*b*) Chalcopyrite, from the same locality as the preceding.

7. Kirkpatrick, A. K., Smith's Falls, Ont., per H. P. Brumell :—
Marl, from White Lake, township of Huntingdon, Hastings county, Ont.

8. Koksilah Quarry company; Victoria, B.C. :—
A block of dressed stone from a quarry on the bank of Koksilah River, two miles south of Koksilah station, on the Esquimalt and Nanaimo railway, thirty-five miles north of Victoria, B.C.

9. Lanigan, R., Calumet, Pontiac county, Que. :—
Kaolinite, from lot 5, range VI. of Amherst, Ottawa county, Que.

10. McVicar, D. W., Tenycape, Hants county, N. S. :—
Pyrolusite, Tenycape Manganese mines, Hants county, N.S.

11. Montpetit, A. N., Ottawa, Ont. :—
Chromic iron ore, from block A. and B. Black lake, Coleraine, Megantic county, Que.

12. Nellis, T. F., Ottawa, Ont. :—
Phlogopite with actinolite, from lot 10, range XII. of the township of Hull, Ottawa county, Que.

13. New Glasgow Iron, Coal and Railway Co,. Ltd., Ferrona, Pictou county, N.S., per R. E. Chambers :—
Numerous specimens of limonite, manganese ore and barytes.

14. Ogilvie, William, Ottawa, Ont. :—
A group of calcite crystals from the Arctic coast, immediately west of the Mackenzie river delta. Collected by Count E. de Sainville.

15. Scott, Walter, Illecillewaet, B.C., per Dr. H. M. Ami :—
(*a*) Steatite with dolomite, from near Ross Peak, six miles east of Illecillewaet, West Kootanie district, B.C.
(*b*) Actinolite, from Illecillewaet, West Kootanie district, B.C.

16. Topley, H. N., Ottawa, Ont. :—
Garnet crystals from Queen Charlotte Islands, B.C.

17. Wertheim, E., Coleraine, Que., per Dr. R. W. Ells :—
Aragonite on chrysotile, from lot 27, range B. of Coleraine, Megantic county, Que.

Contributions to museum—*Cont.*

18. Willimott, C. P., & Co., Ottawa, Ont. :—

(*a*) Garnet, from Wakefield, Que., two specimens, cut and polished.

(*b*) Vesuvianite, from Harrington, Que. Two specimens, cut and polished.

(*c*) Tourmaline, from Wakefield, Que. Two specimens, cut and polished.

(*d*) Apatite, from Portland, Que. One specimen, cut and polished.

(*e*) Amethyst, from Lake Superior, Ont. One specimen, cut and polished.

19. Wilson, J. A., Hudson's Bay Co., Rigolet, per A. P. Low.

A specimen of labradorite, from Isle St. Paul, Labrador.

Educational collections supplied.

"Mr. C. W. Willimott's time has been largely occupied in making up collections of minerals for various Canadian educational institutions.

"The following is a list of those to which such collections have been sent:—

1. High School, Meaford, Ont	consisting of	139	specimens.
2. Collegiate Institute, Goderich, Ont	"	139	"
3. Cowansville Academy, Cowansville, Que	"	100	"
4. High School, Windsor, Ont	"	139	"
5. Grammar School, Woodstock, N.B.	"	100	"
6. High School, Fredericton, N.B.	"	139	"
7. Academy of Bedford, Bedford, Que	"	100	"
8. Collegiate Institute, Woodstock	"	139	"
9. High School, Orangeville, Ont	"	136	"
10. Model School, Magog, Ont	"	100	"
11. High School, Welchpool, Campobello, N.B.	"	139	"
12. McMaster University, Toronto, Ont	"	185	"
13. Moulton Ladies College, Toronto, Ont	"	100	"
14. St. François Xavier College, L'Islet, Que	"	136	"
15. Woodstock College, Woodstock, Ont	"	139	"
16. St. Mary's Girl School, Halifax, N.S.,	"	100	"
17. Superior School No. 5, Gaspereaux Forks, N.B		136	"
18. Public School, Bathurst, N.B.	"	100	"
19. Couvent des Sœurs de la Présentation de Marie	"	100	"
20. Grammar School, Sheffield, Sunbury county, N.B	"	100	"
21. Dunham Academy, Dunham, Que	"	100	"
22. Collegiate Institute, Collingwood, Ont	"	136	"
23. Sisters School, Chatham, Miramichi, N.B.	"	100	"
24. Public School, Olinda, Ont	"	100	"
25. Grammar School, St. John, N.B	"	136	"
26. Commercial College, St. Joseph de Lévis, Que	"	135	"
27. Belleville Institute, Belleville, Que	"	136	"
28. Public School, Scarborough Junction, Ont.	"	100	"
29. Academy, Port Rowan, Ont	"	100	"
30. Superior School, Bloomfield, King's Co., N.B.	"	136	"
31. Lachute Academy, Lachute, Que	"	100	"
32. Convent Museum, St. Laurent, Que	"	100	"

Educational collections supplied.

33. High School, Wardsville, Ont............	consisting of	136	specimens.
34. Institut Canadien, Ottawa, Ont...........	"	136	"
35. Superior School, Dorchester, N.B..........	"	135	"
36. High School, Milltown, Charlotte Co., N.B.	"	134	"
37. Superior School, Tracadie, N.B...........	"	135	"
38. Alexandria Public School, Halifax, N.S.....	"	100	"
39. Collegiate Institute, Galt, Ont.............	"	133	"
40. Young Men's Academy, Sherbrooke, Que...	"	103	"
41. Normal School, Ottawa..................	"	135	"
42. Normal School, Toronto, Ont..............	"	100	"
43. Collegiate, Institute, Ottawa, Ont..........	"	136	"
44. Collegiate Institute, Strathroy, Que........	"	136	"

"Collections have also been prepared and forwarded to:—

Banff Museum, Banff......................	consisting of	200	specimens.
Mid-winter Fair, California....................	"	81	"
St. Mary's Academy, Ogdensburg, New York State, U.S.A.—by special request.........	"	103	"
State University, Munich, Germany—Prof. Groth; in exchange......................	"	82	"

"Making a total of 5,830 specimens, aggregating over two tons in weight of material.

Collecting of minerals.

"In addition to the foregoing work, Mr. Willimott visited, during the latter part of the summer, with the object of procuring further material for the making up of collections, and simultaneously, cabinet specimens for the Museum—the townships of Wakefield, Hull, Templeton, Portland, Augmentation of Grenville, Harrington, Bolton, Coleraine, Ireland, Thetford, and Broughton, in the province of Quebec; Sebastopol, Dungannon and Herschell, in the province of Ontario.

"In the prosecution of this work he has succeeded in collecting a large and varied assortment of minerals, and at the same time made many interesting and useful observations in regard to their mode of occurrence. The collection comprised:—

	Specimens.	Weight.
Actinolite......................................	20	
Apatite, crystals..............................	87	
Apatite in calcite.............................	77	
Biotite..	40	
Bornite..	10	
Chrome garnet in diopside and calcite.........	20	
Chromite......................................	5	150 pounds.
Chlorite.......................................	30	
Chloritoid schist..............................	10	50 "
Chrysotile....................................	40	
Chrysotile in serpentine......................	3	60 "
Diorite	65	
Epidote with garnet...........................	70	
Garnet	100	
Garnetiferous gneiss	50	

Collecting of minerals.

	Specimens.	Weight.
Gneiss	57	
Grossularite	100	
Idocrase	125	
Limestone, crystalline	80	
Magnesite	3	100 pounds.
Orthoclase	24	
Phlogopite, crystals	98	
Phlogopite with calcite, etc	50	
Rutile	60	
Serpentine, from Bolton	40	
Serpentine, from Coleraine	1	100 "
Scapolite	67	
Sodalite	120	150 "
Strontianite	53	
Wernerite	50	
Wollastonite in calcite	80	
Miscellaneous	100	
Total specimens collected	1,735	

" Amongst the foregoing were many exceptionally handsome cabinet specimens."

LITHOLOGY.

Lithology.

Mr. W. F. Ferrier, lithologist, reports on the work of the past year as follows :—

" Early in January, the special stratigraphical collection of Canadian rocks prepared for the Chicago Columbian Exposition was returned, unpacked, and placed in cases in the museum. This involved some labour, as the old museum cases were removed and replaced by those used for the special collection at Chicago, which are of better pattern. At the same time the collection of rocks already in the museum was thoroughly gone over, and a great many duplicate specimens removed. We now have an excellent series of Canadian rocks from the lowest Archæan to the Post-Pliocene, the Archæan being especially well represented. The printed catalogue prepared for the Chicago collection adds largely to its usefulness, permitting of a ready reference to any rock in this collection.

" Reports have been prepared for publication on the microscopical character of a large series of Archæan rocks collected by Mr. Tyrrell from the vicinity of Lake Winnipeg, and on the rocks collected by Dr. Dawson in the Kamloops district, British Columbia. Additional sections have been made of the rocks of the Sudbury district collected by Mr. A. E. Barlow, and it is hoped soon to have the notes on these completed, and added to those already prepared. Work has also been commenced on the series of rocks collected by Mr. Barlow from the

regions covered by the Nipissing and Temiscaming sheets, Nos. 131 and 138 respectively, of the Ontario geological maps. Lithology—*Cont.*

"The work on Mr. Ingall's rocks from Ottawa county is also proceeding, and will soon be brought to completion, while the collections of rocks brought in by Mr. Low from Labrador have been looked over, and some thirty of the more interesting ones have been selected to be cut and examined.

" A collection of Canadian rocks is being prepared for McGill College, also a small series of typical Archæan rooks for Prof. H. A. Nicholson, of the University of Aberdeen. A few specimens of lithographic stone and other rocks have been sent to the Director of the Geological Survey of Newfoundland at his request, for comparison with similar specimens there. Prof. Groth, of Munich, having presented a valuable named series of about 100 German and Austrian rocks, a collection of Canadian Archæan rocks is being prepared for him in exchange. These foreign rocks are especially useful for reference in the determination of Canadian specimens, as the majority of them are from typical localities, and their stratigraphical and petrographical relations have been fully described in various publications.

" As usual, much work of a miscellaneous character has been carried out, including microscopical and blowpipe examinations of various building stones, clays, sands, gravels and minerals handed to me from time to time during the year.

" Owing to the rapid increase in the collection of thin sections of rocks, it has become desirable to arrange these in such a way as to be readily accessible to any one wishing to consult them. With this end in view, I have commenced to re-label and arrange these sections, giving to each a number, by which it can at once be identified. When the work is completed, they will be placed in a special cabinet and a catalogue prepared."

MINING AND MINERAL STATISTICS.

Mr. E. D. Ingall, reports as follows on this work, under his charge, which, since the report for last year has been prosecuted on the usual lines. Mineral statistics.

"The earlier months of 1894 were occupied with the collection of statistical and other data for the report on mining in Canada during 1893, including the compilation and revision of a very large amount of scattered material and its concentration in the final form in which it appears in the report.

Mineral statistics—*Cont.*

"A preliminary summary of the mineral production for 1893, was prepared by the 5th April, and issued shortly afterwards.

"Owing to the lack of funds, the usual field work could not be undertaken. So that proposed investigations of a number of important mining experiments which were being prosecuted in various parts of the Dominion had to be postponed. The same cause further delayed the printing of the report for 1892. This was, however, accomplished later and the proof-reading connected therewith was done during the latter months of the year.

"Much of the time which would under ordinary circumstances have been devoted to field work, was employed in the classification of our reports, plans and other available information relating to individual economic mineral deposits throughout the Dominion. This has been largely accomplished, and we have now the nucleus of a series of records of mines and mineral deposits, which can be continually added to, arranged for easy and ready reference.

"In July I attended the combined meeting of the Quebec and Nova Scotia Mining Associations held at Sydney, Cape Breton, and was hereby able to extend my personal acquaintanceship with the mining districts and operations. Visits were made to a number of the collieries as well as to the Coxheath copper mines.

"In the latter part of the year, the usual preparations were begun for issuing the circulars, &c., necessary for the collection of information of mining operations.

"As in past years numerous memoranda were prepared in answer to the inquiries of correspondents, some of which, from their wide scope took much time.

"Messrs. H. P. Brumell and L. L. Brophy, have, as heretofore, rendered efficient assistance in various branches of the work above referred to."

PALÆONTOLOGY AND ZOOLOGY.

Palæontology and zoology.

Mr. Whiteaves reports as follows upon the work done in these branches of the department :—

"The letterpress of the second part of the third volume of 'Palæozoic Fossils,' referred to in the Summary Report of 1893, as having been commenced, has been completed and is now ready for publication. The part, as completed, is a monograph of the fossils of the Guelph formation of Ontario, consisting of about seventy pages of closely written foolscap, and will be illustrated by seven full page lithographic plates,

which have been drawn on stone by Mr. O. E. Prudhomme, from original drawings made by Mr. L. M. Lambe. Palæontology.

"Through the kindness of the President and Fellows of the Geological Society of London, the Cretaceous fossils collected by Sir James Hector, in various parts of Manitoba, the North-west Territories and British Columbia, during Captain Palliser's exploring expedition in 1857–60, have been lent to the writer for examination and study. A paper, in which the species represented in these collections are identified in accordance with the present state of our knowledge of the fossils of the Cretaceous rocks of North America, has been prepared for publication in the Transactions of the Royal Society of Canada for 1894. Sir J. Hector's fossils.

"In 1883, Mr. Walter Harvey, of Comox, V.I., made an unusually interesting collection of fossils, from the Cretaceous rocks of Hornby and Denman Islands, in the Strait of Georgia, which has been acquired by the Natural History Society of British Columbia. This collection has been lent to the writer by the society's curator, Mr. John Fannin, and Mr. Harvey has supplemented it by the loan of an additional collection made by himself in the fall of 1874, at Hornby Island. A paper descriptive of some of the more important species in these collections, has been written for the current volume of Transactions of the Royal Society of Canada, and specimens of each of the previously undescribed forms have been presented to the museum of the Survey. Dr. C. F. Newcombe, of Victoria, B.C., has kindly sent to the writer an interesting series of Cretaceous fossils collected by himself at the Sucia Islands in the spring of 1894. This collection contains a few forms that are either new to science or new to the Cretaceous fauna of these islands, especially a fine new species of *Cypræa*, and a list of the (thirty-four) species represented has been made and forwarded to Dr. Newcombe. The information gained from an examination and study of all these collections will be incorporated into the fourth and concluding part of the first volume of 'Mesozoic Fossils,' which is intended to consist of a revision of the fauna of the Queen Charlotte and Vancouver groups of islands, and which, it is hoped, will be completed in the spring. A preliminary examination has also been made of some Triassic fossils recently collected by Dr. G. M. Dawson, at several localities in British Columbia, and of small collections of Tertiary and Post-tertiary fossils made last summer by Dr. Newcombe at Carmanah Point and Sooke, V.I., and at the Sucia Islands. Fossils from British Columbia.

"As will be seen by the detailed list which follows, the number of additions to the zoological series in the museum during the past year has been unusually large. Among them, are a good example of Zoological collections.

Zoological collections.

the wapiti, two tusks of the narwhal, and a magnificent specimen of a large and probably undescribed alcyonarian, nearly three feet in height, collected at Work Inlet, near Port Simpson, B.C., and presented by Mr. O. J. Klotz. At the close of 1893, the Survey's series of the eggs of Canadian birds numbered not quite 100 species. Professor Macoun's extensive collections of this year in Assiniboia, have increased this number by sixty-four, and, in exchange for some of his duplicates, eggs of some thirty-five additional species have been obtained from Mr. Walter Raine. Mr. Low, also, during the spring of 1894, obtained an interesting series of bird's eggs from the Hamilton River, Labrador, including those of the American merganser, black duck, spruce partridge, osprey and Canada jay. The whole series, which now consists of upwards of 200 species, has been classified and labelled so as to be available for reference. In the fall, Professor Macoun made collections of the land and fresh water mollusca, but more particularly of the Unionidæ, of south-western Ontario. Since receiving these, the writer has prepared a systematic list of all the recent Unionidæ in the museum of the Survey, for publication in the 'Canadian Record of Science.' It gives the names of all the species known to occur in the Dominion, and to ensure as much accuracy as is attainable, specimens of most of the nominal species of *Anodonta*, and a few of the more critical forms of *Unio* have been kindly compared by Mr. Charles T. Simpson, with Dr. Lea's types of North American Unionidæ in the United States National Museum at Washington. The whole of the Survey's rather extensive collection of Canadian land and fresh water shells, too, has been re-labelled in accordance with the latest nomenclature. While attending the meeting of the American Association for the Advancement of Science, at Brooklyn, about eighty species of shells were obtained for the museum, in exchange for some of its duplicates. Two mammals, forty-seven birds, two turtles, and one snake, have been mounted by Mr. S. Herring, who has, as usual, gone over and cleaned all the mounted vertebrates in the museum. The collection of mounted birds and mammals which has been in course of preparation for the museum in connection with the Rocky Mountain Park at Banff, is now nearly completed and will shortly be despatched to its destination. It consists of eight specimens of Canadian mammals, and 259 Canadian birds, and a turtle, all of which have recently been mounted upon suitable stands and properly labelled.

Work by Mr. Weston.

"Mr. T. C. Weston, from the first of January to the seventeenth of March (when he received his leave of absence) was occupied in museum work in the palæontological and ethnological collections, in labelling and arranging new specimens, in checking off

the specimens and models of gold returned from the World's Fair at Chicago, and reproducing such models as were not returned, in making numerous microscopic sections of rocks and fossils, &c. Previous to his superannuation on the first of August, he was granted four months leave of absence, and during most of this time he employed himself in collecting numerous fossils for the museum, from the Quebec group in and near Quebec city.

Palæontology.

"The greater part of Dr. Ami's time has been occupied in determining the numerous collections of fossils brought in by officers of the department and others. Lists of the organic remains found associated with the ores of the Trunk Road Iron mine at Arisaig, Antigonish county, and those of the Nictaux iron ore district in Annapolis county, Nova Scotia, were prepared to supplement geological investigations recently carried on by Mr. Hugh Fletcher and Dr. L. W. Bailey in that province. A palæontological appendix to Dr. Ells's report on the geology of the south-western portion of the province of Quebec has been almost completed. This will contain lists of the species contained in the collections made by Dr. Ells, Dr. W. E. Deeks, Messrs. J. F. Whiteaves, T. C. Weston, the late James Richardson and others, from the Eastern Townships, between Lake Champlain, Lake Memphremagog and Montreal.

Work by Dr. Ami.

"Early in the year some 300 specimens of Canadian and foreign fossils were determined and labelled for the authorities of the museum of St. Laurent College, Montreal. A smaller collection sent by Mr. H. H. Blanchet was also determined and returned during the past year. The contents of the unclassified boxes of duplicate specimens in the largest room in the basement have been arranged chronologically and according to the provinces in the Dominion, and not much less than one thousand specimens of fossils were placed in the drawers of duplicate specimens (available for collections), which are fast being exhausted. Lists have been prepared of such of the fossils in the museum as are still unlabelled. A manuscript bibliography of Canadian palæontology has been continued, which will soon be completed and brought up to date. Records of additions to the palæontological and ethnological collections have been kept.

"Systematic lists of fossils were prepared as follows:

Lists of fossils prepared.

For Dr. R. W. Ells:—Specimens from nine localities in the south-western portion of the Province of Quebec.

For Mr. T. C. Weston:—Specimens from several localities in or near the City of Quebec.

For Mr. McInnes:—Specimens from Campement d'Ours, Lake Huron.

Palæontology —*Cont.*

For Dr. R. Bell:—Specimens from fourteen localities in the Manitoulin Islands and Georgian Bay, Ont.

For Mr. N. J. Giroux:—Specimens from thirteen localities in the vicinity of Joliette, Que.

For Mr. Hugh Fletcher:—Specimens from six localities in various parts of Nova Scotia.

For Dr. L. W. Bailey:—Specimens from eight collections in the Nictaux and Moose River districts of Nova Scotia.

Some miscellaneous collections from twenty-four localities in Ontario, Quebec, New Brunswick, Nova Scotia and Newfoundland.

"A preliminary study has also been made of the large collection of Silurian fossils collected by Mr. A. E. Barlow at Lake Temiscaming, of several collections of graptolites from the Eastern Townships, Rocky Mountains, Lower St. Lawrence, &c., collected by officers of the Survey and others.

Collections of fossils supplied.

"Collections of duplicate fossils have been sent to the following educational institutions in the country, or in exchange for other specimens:

1. Montreal High School, Montreal, Que. Collection of fossil plants from the coal formations of Canada.
2. Michigan University, Ann Arbor, for Dr. Carl Rominger. Specimens of *Prototaxites Logani*, Dawson.
3. Provincial Museum of British Columbia. 169 specimens.
4. Prof. S. Calvin, State Geologist, Iowa. 156 specimens of Canadian fossils, in exchange for Devonian fossils received.
5. Mount St. Louis Academy, Montreal, Que. General collection 247 specimens.
6. Clarenceville Academy, Clarenceville, Que. General collection 220 specimens.
7. Shelburne Academy, Shelburne, Nova Scotia. General collection 320 specimens.
8. Peter Redpath Museum, McGill University, Montreal, Que. Middle Cambrian fossils from British Columbia, 23 specimens.
9. Rocky Mountain Park Museum, Banff, Alberta. Collection of Rocky Mountain fossils from Mt. Stephen and Anthracite. 23 specimens.
10. Museum of the Provincial University of Manitoba, Winnipeg, Man., 156 specimens, chiefly Devonian fossils from Lake Winnipegosis.

"The collection of fossils prepared last year for the World's Columbian Exposition, Chicago, was this year forwarded to the Ontario School of Mining, Kingston. Palæontology —Cont.

"Collections have been submitted during the year to the following gentlemen for examination:—

"A series of sixty-one specimens of Canadian Palæozoic Ostracoda to Prof. T. Rupert Jones, F.R.S., London, the best authority on these minute organisms; a collection of fifty specimens of Pleistocene plants submitted to Sir J. W. Dawson, F.R.S., of Montreal, and a few specimens to Prof. C. D. Walcott and T. W. Stanton, Washington, D. C.

Work by Mr. Lambe.

"During the past year Mr. Lambe has concluded a detailed study of the recent marine sponges of the North Pacific coast of America from British Columbia to the Arctic Ocean. These studies, begun in 1892, were mainly based upon collections made by Dr. Dawson in British Columbia and Behring Sea and recently supplemented by important material from Alaska, &c., collected by Dr. W. H. Dall and loaned by the Smithsonian Institution, and by some specimens obtained by Professor Macoun in 1893 off the coast of Vancouver Island. Two papers descriptive of the species represented in Dr. Dawson's collections, have been published in the Transactions of the Royal Society of Canada for 1892 and 1893, and this year these have been supplemented by a paper descriptive of the sponges collected by Dr. Dall, which will appear in the current volume of the same publication. This last paper consists of detailed descriptions of twelve apparently new species, and determinations of twenty others from seventy-one localities. The paper is illustrated by three quarto plates.

"He has also been engaged in assisting the writer in ascertaining the characters and relations of certain fossils from the Guelph formation of Ontario and of some fossils from the Cretaceous rocks of the Pacific Coast, and in making drawings of some of them to illustrate the reports or papers already mentioned.

"In October last, at the writer's suggestion, he began a study of Canadian fossil corals, having for its object a revision of this important and imperfectly understood group, and the discovery of any new facts that may throw light upon stratigraphical problems or be of interest to the systematic palæontologist.

Contributions to Museum.

"The following is a list of specimens collected by officers of the Survey during the year 1894:—

Dr. G. M. Dawson:—

About forty specimens of Triassic fossils, fifty of Tertiary plants, eighteen of Tertiary insects, from British Columbia, and a few fossils from the Laramie of Highwood River, N.W.T.

Contributions to museum—*Cont.*

A number of Indian arrow and spear heads from British Columbia. Indian pipe from Nicola, B.C.

Professor Macoun :—

1,000 eggs of sixty-four species of Canadian birds, over 300 skins of birds and small mammals, about twenty species of fishes, a large series of reptiles, twenty-seven species of butterflies, and twenty-five species of land and fresh water shells from western Assiniboia, also a large series of land and fresh water shells from south western Ontario.

Dr. R. W. Ells and N. J. Giroux :—

Twenty-seven species of fossils from the Township of Nepean, Carleton, Ont., nineteen from the Trenton limestone at Hull, Que., thirty from the Trenton limestone at Hog's Back, Nepean, Ont., and three small slabs of fossils from Gloucester Township, Ont.

Hugh Fletcher :—

Seventeen specimens of Silurian fossils from the Trunk Road Iron Mine, Arisaig, N.S. About twenty specimens of Cambro-Silurian fossils from McNeil's Brook and Doctor's Brook, Arisaig, N. S.

R. Chalmers :—

Eighty specimens, representing about twenty species, of shells from the Leda Clay of the Baie des Chaleurs region. About a dozen specimens of four species of shells from the boulder clay at Negrotown Point, St. John, N. B.

A. P. Low :—

Eggs of fourteen species of birds from the Hamilton River, Labrador.

Two nests and eggs of Canada jay from Hamilton Inlet.

One skeleton each of the wolverene and lemming, three skins of the jumping mouse, one skin and skeleton of field mouse, twenty bird skins, and two skins of the land-locked salmon ; all from the Hamilton River.

Collection of shells from Hamilton Inlet.

Seven small species of fossiliferous, bituminous and shaly limestone from Port Burwell, Cape Chidleigh, Labrador (loose).

J. McEvoy :—

Two stone pestles from Kamloops, B. C.

T. C. Weston :—

One hundred specimens of fossils from the *Shumardia* limestones at Point Lévis, Que., and one hundred and fifty from the limestones at Quebec city.

Contributions to museum—*Cont.*

Dr. H. M. Ami :—

About sixty specimens of fossils from Sargent's Bay, Lake Memphremagog, fifty from the Trenton quarries at Hull, Que., and twenty specimens of *Scolithus* from the Potsdam sandstone of Carleton, Ont. A collection of Pleistocene shells from the railway cutting near Gilmour's grove, Chelsea, Que.

Specimen of the Jumping Mouse (*Zapus Hudsonicus*), from Tuck's Landing, Lake Memphremagog.

Dr. H. M. Ami and L. M. Lambe :—

About one hundred specimens of fossilferous nodules from Besserer's wharf, near Ottawa, Ont.

L. M. Lambe :—

One specimen of a star-fish from the Trenton limestone of the Ottawa district.

A. E. Barlow :—

500 specimens of Silurian fossils from the shores and islands of Lake Temiscaming.

One arrow head from Lake Temiscaming.

Hugh Fletcher and Dr. Bailey, per Dr. A. H. McKay :—

Fifteen collections of fossiliferous rocks and fossils from the Nictaux iron ore district, Annapolis county, N.S.

"The additions from other sources to the palæontological, zoological and ethnological collections during the year, are as follows :—

" *By presentation :—*

Sir J. W. Dawson, Montreal :—

Five specimens of *Pupa vetusta* and one of *Pupa Bigsbyi* from the South Joggins, Nova Scotia.

Five photographs of Carboniferous land shells from Canada and the United States.

Specimens of five species of *Naiadites* and *Anthracomya* from Nova Scotia and Cape Breton.

Colonel C. C. Grant, Hamilton, Ont. :—

Thirty-one specimens of fossils from the Clinton and Niagara formations at Hamilton, Ont.

Thos. G. Connon, Brocton, N.Y. :—

Fine specimen of *Orthoceras Scammoni*, McChesney, from the Guelph formation, Elora, Ont.

Contributions to museum—*Cont.*

J. A. Valin, Ottawa :—

Two pyritized *Orthoceratites* (probably *Endoceras proteiforme*) from the Utica shale, near Ottawa.

C. Constantine (Mounted Police) :—

Molar of Mammoth, from the Yukon river, near Nulatto.

J. A. Dresser, B.A., Aylmer, Que. :—

Three fragmentary specimens of *Pentamerus Knightii*, from Dudswell, Que.

Otto J. Klotz, Ottawa :—

Tooth of Killer whale.

Four species of Cretaceous fossils, from Moose Jaw or Great Bend Creek, Manitoba.

Fine specimen of an Alcyonarian, from Work Inlet, near Port Simpson, B.C.

Dr. C. F. Newcombe, Victoria, B.C. :—

Two rare species of Cretaceous fossils, and five from the Pleistocene of the Sucia Islands, Gulf of Georgia.

Walter Harvey, Comox, B.C. :—

Five species of Cretaceous fossils, from Hornby Island, B.C.

One rare species of Buccinum, from Alert Bay, B.C.

W. A. Fraser, Toronto, Ont. :—

Specimen of *Placuna placenta*, from Trincomalee.

Twenty specimens of Burmese shells.

W. E. Saunders, London, Ont. :—

One female Musk Turtle (*Aramochelys odoratus*), and one small Map Turtle (*Malacoclemys geographicus*) from Rondeau, Ont.

Fine living example of the "Blowing Viper" or Hog-nose Snake (*Heterodon platyrhinus*, Latreille), from London, Ont.

Richard Lake, Grenfell, Assa. :—

Eggs of fifteen species of Canadian birds, from Assiniboia.

Albert J. Hill, New Westminster, B.C. :—

Fine specimen of *Zirphœa crispata*, L., from Tacoma, Wash.

W. Borthwick, Ottawa :—

Live specimen of a scorpion, found among bananas.

Alex. Crowe, Ottawa :—

Nest and one egg of Chimney Swift (*Chætura pelagica*), from near Ottawa.

A. G. Kingston, Ottawa :—

Nineteen specimens of eggs of ten species of Canadian birds.

A. McL. Hawks, Tacoma, Wash. :—

Three fine specimens of *Zirphœa crispata*, from Tacoma, Wash. Contributions to museum—*Cont.*

Ambroise Charbonneau, Hull, Que. :—

Two enteroliths from gut of Sucker caught in the Madawaska

Jean Parent, Billing's Bridge, Ont. :—

One young Red-tailed Hawk (*Buteo borealis*).

James Fletcher, Ottawa :—

Three specimens of *Planorbis nautileus*, var. *cristatus*, from ponds at St. Louis dam, Ottawa.

C. Esdale, Ottawa :—

Albino European House Sparrow (*Passer domesticus*) from New Edinburgh.

John McMenomy, Jun., Metcalfe, Ontario :—

Male American Hawk Owl (*Surnia ulula caparoch.*)

Dr. C. J. H. Chipman, Ottawa :—

Saw-whet Owl (*Nyctale Acadica*).

Duncan Mathewson, Ungava Bay, per A. P. Low :—

Two tusks of the Narwhal.

Collection of Eskimo carved ivory.

J. A. Wilson, Rigolet, per A. P. Low :—

Skin of Ivory Gull.

H. M. S. Cotter, North-west River, Hamilton Inlet, per A. P. Low :—

Collection of Esquimaux carved ivory.

Model of Eskimo kayak.

Two bird skins.

Joseph Michelin, North-west River, per A. P. Low :—

Skin of Jumping Mouse.

Skin of Flying Squirrel.

John Grey, Pembroke, Ont. :—

Indian spear head of white jasper, from the Petewawa River.

C. D. Graham, Ottawa :—

Iron axe head and iron ramrod, Grand Lake, Gatineau valley.

John Perry, Aylmer, P.Q. :—

Arrow head found above Aylmer.

A. B. Clark, Shuswap, B.C. :—

Mortar, found in bank of South Thompson River.

Pestle, South Thompson valley.

Contributions to museum—*Cont.*

Capt. Bloomfield Douglas :—

Stone arrow-head found near Forteau Bay, Labrador.

J. S. Larke, Commissioner for Canada, World's Columbian Exposition, Chicago :—

Ancient Indian pottery from Kansas, U.S.A.

J. Ballantyne, Ottawa :—

Stone gouge, found in Graham's brick yard, Ottawa.

Rev. D. Jennings, M.A., Port Essington, B.C. :—

Medicine man's charm.

By Exchange :—

Eggs of thirty-five species of Canadian birds.

Eighty species of exotic shells.

By Purchase :—

Twenty Cretaceous fossils from the North-west Territories.

NATURAL HISTORY.

Natural history.

Under this head Professor Macoun reports as follows :—

" After the date of my last summary report, I was for some time occupied in completing the examination of the collections made on Vancouver Island and in bringing up to date the catalogue of Canadian birds, which was accomplished before I took the field last May.

Fauna and flora of the North-west.

" It was decided that the past summer should be the first of several seasons devoted to field work on the fauna and flora of the North-west, where many gaps in our knowledge remain to be filled, before it will be possible to give a collective account of the natural history of that great country. With this purpose in view, Mr. William Spreadborough was instructed to proceed to Medicine Hat, Assiniboia, on the first of April, and commence work by securing skins of the birds which pass that point during their spring migration. Mr. Spreadborough is well fitted for this work, as in addition to his previous knowledge of birds he had acted as field assistant for me every season since 1889. In 1891 he was stationed at Banff early in the season, in 1892 at Indian Head, and if possible it is intended to station him at Moose Jaw or some other suitable point in the spring of 1895. When this work has been completed, it will be possible to trace the main lines of migration of the various species as well as their distribution in longitude.

" On May 30th I joined Mr. Spreadborough, and after a few days spent in the vicinity of Medicine Hat and Lethbridge, we, on June 8th, moved camp to Crane Lake, eighty miles to the eastward. Crane

Lake was chosen as a collecting and observing point because of the numerous lakes and marshes in that vicinity about which many species of water-fowl and waders were breeding. Within a radius of ten miles, we collected the eggs of sixty-four species of birds and made notes of their nesting habits. A complete list of the plants growing in that neighbourhood was also made, and specimens of over 300 species were collected. Fourteen days were spent in this work and on June 22nd, we drove out to the North Branch of Swift Current Creek, in Cypress Hills, a distance of twenty miles, and collected there until the 30th, when we returned to Crane lake. Here I found, to my great regret, instructions waiting me to close the field work and return to Ottawa, which was accordingly done.

Natural history—*Cont.*

"My collections for the season consisted of over 500 species of plants, about 1000 eggs, and over 300 skins of birds and small mammals; about twenty species of fishes, and twenty-seven species of butterflies. All but the bird skins, which were collected earlier in the season, were the result of five weeks work. Further collections, including one of 550 species of plants, were made in the vicinity of Ottawa during the latter part of the summer.

Collections made.

"During the spring of this year, I examined collections of plants made by Mr. Jas. Tyrrell in the Barren Grounds, Mr. James Bain at Laggan in the Rocky Mountains, Mrs. Brodie in the neighbourhood of Quebec and Toronto, and by Mr. John Moser in New Brunswick, besides many smaller collections. This autumn I have examined and named over 1,000 species of our own collecting, those collected by Mr. A. P. Low, in Labrador, a collection from the region of the Canada-Alaska boundary made by Mr. Otto Klotz and one of his assistants Mr. Canavan, and a collection from Niagara Falls by Mr. Roderick Cameron.

Collections of plants examined.

"For some years past the greater part of the work connected with the determination of flowering plants and their arrangement in the herbarium has been in charge of my assistant Mr. James Macoun, but during his absence on special service in connection with the Behring Sea Commission this work fell considerably into arrears. On his return to this Department in July, 1893, most of the collections of 1891 and 1892 had still to be worked over, and this occupied the greater part of the winter months. A certain number of duplicates were also arranged by him for distribution. Two of the herbarium cases were also re-arranged in a permanent manner. This work will be continued as time permits.

Herbarium.

"Since December 31st, 1893, 2,808 sheets of botanical specimens have been sent to scientific institutions and individuals, for the most

Natural history—*Cont.*

part in exchange for specimens received for our herbarium. The herbaria to which the largest number of specimens were sent, are :—

British Museum	379
United States National Museum	260
University of California	358
Kew Gardens	177
Harvard University	451
Columbia College	349
San Francisco Academy of Sciences	200

Exchanges of plants.

"Specimens have been received from all the institutions mentioned above with the exception of the British Museum and Kew. In addition to these, many valuable contributions have been received from individuals and institutions not included in the above list. Among the more important of these is an almost complete series of the flowering plants of Norway, consisting of 1,257 species from the Botanical Museum at Christiania; more than 1,000 species of cryptogams from the herbarium of the distinguished bryologist, Dr. Lindberg; a full set of the algæ of Greenland, from the University of Copenhagen, which completes the collection of the flora of Greenland, sent us from Copenhagen; 400 species of fungi from Dr. Ellis, and smaller collections from New South Wales and Natal. It still remains to supply Canadian specimens in exchange for most of the above collections, and until this has been done I cannot avail myself of further advantageous offers of exchange, received.

"The arrangement of the collections of plants and birds intended for the museum of the Rocky Mountain Park, at Banff, Alberta, has also occupied some time. These collections constitute an almost complete representation of the birds and flowering plants found within the limits of the park."

Report by Mr. J. Fletcher.

Mr. James Fletcher, in charge of the entomological collections, makes the following report upon them :—

"I have to report that the collections are all in an excellent state of preservation, and that valuable additions have been made during the past year. The most important of these are the following :—

1. A collection of Coleoptera containing many rare and little known species from the Queen Charlotte Islands and the adjacent part of British Columbia. This collection was made by Rev. J. H. Keen, of Massett, Q.C.I., and contains over two hundred species, most of which are worked out and mounted ready for the cabinets.
2. A general collection of insects made chiefly by Mr. Otto Klotz; but also by other members of the Canada-Alaska boundary survey.

3. Collections of Lepidoptera made by Prof. Macoun and Mr. J. McEvoy, in Assiniboia and the Kamloops district of British Columbia respectively. Entomological collections.
4. A collection of Lepidoptera and Coleoptera, made by Mr. A. P. Low, in Labrador. This is a small collection, but contains some very interesting species.
5. A small collection made by J. C. Gwillim, at Moose Jaw, N.W.T., and Wabigoon, Ont.

" With the exception of a few of the specimens in Nos. 1 and 2, in the above list, all of the insects in these collections have been identified and listed, and are ready for arrangement in the cabinets.

" In addition to the above, type specimens of three new species of Orthoptera have been received from Mr. A. P. Morse, of Wellesley, Mass., viz., *Spharagemon æquale*, Say sub-sp. *Scudderi*, Morse ; *S. saxatile*, Morse, *S. bolli*, Scudder."

MAPS.

Mr. James White was, on April 9th last, placed in charge of the mapping and draughting work, as successor to the late Mr. Scott Barlow, although not formally appointed till Oct. 26th. Much of his time has been occupied in rearranging the maps and plans in the office, but this cannot be successfully completed till such time as it may be possible to index and catalogue the whole. The ordinary routine work in connection with the laying down of projections and supervising the draughting generally has also been attended to. In addition, some progress has been made toward the completion of an index of altitudes throughout Canada. Maps.

In the subjoined list, it will be observed that a number of the maps given in the corresponding list of last year as incomplete or ready for the engraver, reappear in the same condition, while considerable numbers have been added as ' ready for engraving.' This results chiefly from the small amount of money, in proportion to the work, which it has been found possible to devote to map engraving and printing during the past year. The accumulation of unpublished material of this kind is becoming a source of embarrassment and must be regarded also as a loss to the public. In addition to the maps enumerated below, there are several others which have already been compiled, but which it has not been decided to publish in their present form. There are also some for which the whole of the material has been collected, but of which it has not yet been possible to complete the compilation and draughting. Delays in publication.

Maps.

Maps in course of preparation and published during the past year :—

	Area Sq. Miles.
British Columbia, Kamloops sheet (Dr. Dawson), in hands of engraver. Scale 4 miles = 1 inch	6,400
British Columbia, Shuswap sheet (Dr. Dawson), in progress.. Scale 4 miles = 1 inch	6,400
British Columbia, West Kootanie sheet (Mr. McConnell), in progress. Scale 4 miles = 1 inch	6,400
British Columbia, exploratory survey of the Finlay and Omenica rivers (Mr. McConnell), ready for engraver. Scale 8 miles = 1 inch	7,000
Athabasca Territory and British Columbia (three sheets), to illustrate the work of Mr. McConnell, 1889-90, and extending from longitude 110° W. to 120° W. and latitude 54 N° to 60° N., ready for engraver. Scale 8 miles = 1 inch	150,000
North-eastern Manitoba, Lake Winnipeg, (Mr. Dowling), ready for engraver. Scale 8 miles = 1 inch	20,000
North-western Ontario, Sheet No. 6, Seine River Sheet, (Messrs. Smith and McInnes), ready for engraver. Scale 4 miles = 1 inch	3,456
North-western Ontario, Sheet No. 9, Lake Shebandowan sheet, (Mr. McInnes), ready for engraver. Scale 4 miles = 1 inch.	3,456
North-western Ontario, Lake Nipigon, (Messrs. McInnes and Dowling), in progress. Scale 4 miles = 1 inch	3,900
Ontario, Sheet No. 129, Mississagui River sheet, (Dr. Bell), in progress. Scale 4 miles = 1 inch	3,456
Ontario, Sheet No. 126, Manitoulin Island sheet, (Dr. Bell), in hands of engraver. Scale 4 miles = 1 inch	3,456
Ontario, Sheet No. 125, French River sheet, (Dr. Bell), ready for engraver. Scale 4 miles = 1 inch	3,456
Ontario, Sheet No. 131, Lake Nipissing sheet, (Mr. Barlow), ready for engraver. Scale 4 miles = 1 inch	3,456
Ontario, Sheet No. 138, Lake Temiscaming sheet, (Mr. Barlow), nearly ready for engraver. Scale 4 miles = 1 inch	3,456
Ontario, Kingston and Pembroke mining district, (Mr. White), ready for engraver. Scale 4 miles = 1 inch	1,700
Quebec, Lièvre River and Templeton phosphate mining district, 2 sheets, (Messrs. Ingall and White), in hands of engraver. Scale 40 chains = 1 inch	220
Quebec, N. W., quarter sheet-Eastern Townships map (Messrs. Adams and Giroux), in progress. Scale 4 miles = 1 inch.	7,100

Maps—*Cont.*

	Area Sq. Miles.
Quebec, S.W., quarter sheet, Eastern Townships map, (Dr. Ells) in hands of engraver. Scale 4 miles = 1 inch..........	7,100
Quebec, sketch map of part of Berthier, Joliette, L'Assomption, Terrebonne, Montcalm, Argenteuil and Ottawa Counties, (Dr. Adams), in progress. Scale 8 miles = 1 inch......	3,600
Quebec, township of Brandon (Dr. Adams), ready for draughtsman. Scale 2 miles = 1 inch......................	90
Quebec, Lake St. John district (four sheets), (Mr. Low), in progress. Scale 4 miles = 1 inch......................	13,824
Quebec and North-east Territory, Labrador Peninsula, extending from the Atlantic Ocean to Hudson Bay and from river St. Lawrence to Hudson strait (Mr. Low), in progress..	525,000
Quebec and North-east Territory, Labrador Peninsula (Mr. Low). Scale 150 miles = 1 inch. Published herewith.	
New Brunswick, surface geology (Mr. Chalmers), quarter-sheet 1 N. W., in progress. Scale 4 miles = 1 inch............	3,456
New Brunswick, surface geology (Mr. Chalmers) quarter-sheet, 2 S. W., in progress. Scale 4 miles = 1 inch............	3,456
New Brunswick, surface geology (Mr. Chalmers), quarter-sheet, 2 S. E., ready for engraver. Scale 4 miles 1 = 1 inch...	3,456
New Brunswick and Prince Edward Island, surface geology (Mr. Chalmers), quarter-sheet 5 S. W., ready for engraver. Scale 4 miles = 1 inch..........................	1,500
New Brunswick and Nova Scotia, surface geology (Mr. Chalmers), quarter-sheet, 4 N. W., ready for engraver. Scale 4 miles = 1 inch..........................	3,456
Nova Scotia, Eight sheets, Nos. 25, 26, 27, 28, 29, 30, 31 and 32, Antigonish and Guysborough Counties, (part) (Messrs. Fletcher & Faribault), were published in 1894. Scale 1 mile = 1 inch..............................	2,304
Nova Scotia, Six sheets, Nos. 33, 34, 35, 36, 37 and 38, Antigonish and Guysborough counties, part (Messrs. Fletcher & Faribault), will be published about March, 1895. Scale 1 mile = 1 inch..............................	1,738
Nova Scotia, Fourteen sheets, Nos. 39 to 52 (incl) Pictou and eastern part of Colchester and Halifax counties (Messrs. Fletcher & Faribault), ready for engraver. Scale 1 mile = 1 inch..............................	3,024

Maps—*Cont.*

	Area Sq. Miles.
Nova Scotia, Twenty-one sheets, Nos. 53 to 69(incl) 76, 82, 100 and 101, Halifax Colchester, Cumberland and Hants counties (part) (Messrs. Fletcher & Faribault), nearly ready for engraver. Scale 1 mile = 1 inch................	4,536
Nova Scotia, sketch map of South-western part of Nova Scotia. Prof. Bailey. Scale 8 miles = 1 inch. Published in 1894.	6,400

LIBRARY.

Publications distributed and sold.

Dr. Thorburn, Librarian, reports that during the year ending 31st December, there were distributed 5,666 copies of the Survey publications, comprising reports, special reports and maps, of these 4,077 were distributed in Canada and the balance, 1,589, were sent to other countries. It will be seen that there is a large falling off in the number distributed this year as compared with the previous year when the number sent out was 12,891. This is to be accounted for by the fact that, last year, a considerable number of certain publications were distributed gratuitously at the Chicago Exhibition, and to the further fact that no copies of the Report, Vol. VI., 1892-93, have been sent this year to our general exchange list, the printing of that volume being as yet incomplete.

Sales of publications by the Librarian during the year, including reports and maps numbered 1,707, the amount received therefor being $245.79.

Publications received.

During the year 1894, the number of publications received as donations or exchanges was 2,403, the number purchased 36, and the periodicals subscribed for, 32.

The letters received in connection with the distribution of the publications were 658, besides 784 acknowledgments.

The number of letters sent out from the library was 605, and in addition to these 615 acknowledgments were sent to our exchanges and to others from whom publications were received.

Library.

The number of books bound during the year was 99.

It may be stated that there are now in the library about 10,500 volumes, being largely of a technical character, relating to geological, mineralogical, palæontological, zoological and botanical subjects.

The annex added to the library in 1892, has been nearly filled up with books and there seems no way of further enlarging the accommodation for the library in the present building. Library.

The library is open to the public for reference during office hours, but books are not allowed to be removed from the building.

VISITORS.

During the past year, the number of visitors to the museum has been greater than ever before, amounting to 26,000, an increase of 5,000 over 1893. These include many strangers from almost all parts of the world and it is to be regretted that the dimensions and character of the present building does not admit of a more adequate and striking representation of the mineral wealth of the country. Visitors.

STAFF, APPROPRIATION, EXPENDITURE AND CORRESPONDENCE.

The total present strength of the staff, including all employees, professional and ordinary, is 51. Staff.

During the calendar year the following changes in the permanent staff have taken place :

Mr. Scott Barlow, died.

Mr. W. R. McEwan, died.

Mr. A. S. Cochrane, died.

Mr. T. C. Weston, superannuated.

Mr. James White, appointed chief draughtsman and geographer, vice Mr. Scott Barlow.

Appropriation and expenditure.

The funds available for the work, and the expenditure of the Department during the fiscal year ending 30th June, 1894, were :

——	Grant.	Expenditure.
	$ cts.	$ cts.
Civil list	50,732 50	....
Geological Survey and Museum appropriation	60,182 50	....
Civil list, salaries	....	49,212 33
Exploration and survey	....	36,773 84
Wages of temporary employees	....	17,276 19
Boring operations, Deloraine	....	132 00
Printing and lithography	....	4,856 19
Purchase of specimens	....	51 51
Purchase of books and instruments	....	834 78
Purchase of chemicals and laboratory apparatus	....	265 41
Stationery, mapping materials and Queen's Printer	....	617 35
Columbian Exhibition	....	2,947 45
Incidental and other expenses	....	1,430 42
Advances to explorers on account, 1894-95	....	214 63
		114,612 10
Less—Paid in 1892-93 on account 1893-94 . . $4,075 00 Unpaid 30th June, 1894 . . . 1,142 92	....	5,217 29
		109,394 18
Unexpended balance Civil-list appropriation	....	1,520 17
do do Geological Survey appropriation	....	0 65
	110,915 00	110,915 00

The correspondence of the department shows a total of 9,592 letters sent, and 7,650 received.

I have the honour to be, sir,

Your obedient servant.

GEORGE M. DAWSON,

Deputy Head and Director.

G. M. DAWSON.--Photo. July 22, 1890.

STEIN CREEK AND LOWER SPURS OF THE COAST RANGES.

GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

REPORT

ON THE AREA OF THE

KAMLOOPS MAP-SHEET

BRITISH COLUMBIA

BY

GEORGE M. DAWSON

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY
1895

Note.—The bearings throughout the report are given with reference to the true meridian, unless otherwise specially noted. Average magnetic declination about 24° E.

REPORT

ON THE AREA OF THE

KAMLOOPS MAP-SHEET

BRITISH COLUMBIA

BY

GEORGE M. DAWSON.

PHYSICAL GEOGRAPHY.

The Kamloops map-sheet, to which this report relates, covers a portion of the Interior Plateau of British Columbia, with a comparatively small width of mountains of the adjacent Coast Ranges on its western edge. It is a square of which the sides measure eighty miles, and consequently includes an area of 6400 square miles, all parts of which are in the drainage basin of the Fraser River and its tributaries. Area.

The province of British Columbia, extending from the 49th to the 60th parallel of north latitude, is practically co-extensive with about 900 miles in length of the Cordilleran belt, or Rocky Mountain region of North America. The two principal mountain systems of the Cordillera in British Columbia are the Rocky Mountains proper and the Coast Ranges.* These constitute its north-eastern and south-western borders respectively, if we exclude from consideration the insulated mountains of Vancouver Island and the Queen Charlotte Islands. Between these two limiting systems we find, on the side next to the Rocky Mountains, several less regular, though often equally lofty mountain ranges, which may be collectively referred to under the name The Cordilleran belt.

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*To avoid possible misconception, it must be explained that the Coast Ranges of British Columbia are orographically and geologically distinct from the Coast Ranges of California and Oregon. The name Cascade Range is on some maps extended to them from the mountains of Oregon and Washington to which it rightly applies, but this is wholly inappropriate, as the two mountain systems are entirely distinct, both in trend and in composition.

of the Gold Ranges, and between these and the inner margin of the Coast Ranges, lies the region described as the Interior Plateau.

Both these great bordering mountain systems of the Cordillera are comparatively modern, geologically speaking, while the Gold Ranges are, apparently, much more ancient. The Coast Ranges (with the adjacent mountains of Vancouver and the Queen Charlotte Islands) seem to have been first outlined about the close of the Triassic period and to have been re-elevated and increased in width toward the end of the Cretaceous period; while the Rocky Mountains proper are almost entirely due to movements of the earth's crust referable to the same closing epoch of the Cretaceous.*

The Interior Plateau.

The Interior Plateau of the southern part of British Columbia, may be described as having an average width of about one hundred miles, with a length, from south-east to north-west of about five hundred miles. Its mean height above the sea is probably about 3500 feet, but its elevation decreases gradually in a north-westerly direction, so that the southern part, with which we are more immediately concerned, considerably exceeds the height stated.

Its character and origin.

It is only when regarded in a broad general way and by contrast to the lofty and rugged mountains by which it is bordered, that this interior region can be designated a plateau. Seen from points along its larger and lower valleys, it might be described as a hilly or in places even a mountainous country. More carefully examined, it is found to consist, particularly in its southern part, of numerous blocks of plateau-like contour, separated by important depressions and differing considerably in their actual elevations. But there is every reason to believe that in the early part of the Tertiary period, the area of the Interior Plateau had become reduced by prolonged denudation to the condition of a nearly uniform plain. This condition must have resulted from a long continued period of stability, during which the height of the country relatively to the sea remained constant, enabling the streams to cut their beds down to what has been termed the "base-level of erosion," or to that minimum rate of descent, which, while it sufficed to unwater the district, did not practically admit of further reduction. After this had been attained, however, the reduction of elevations still upstanding between the main watercourses continued, till, in the end, these also approximated to the general level. Though never absolutely flat, the surface of the country thus became an approximate plain or what is know as a "peneplane."

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*Report of Progress, Geological Survey of Canada, 1878-79, pp. 46 B, 48 B; Annual Report, Geological Survey of Canada, vol. II. (N.S.) p. 15 B; Trans. Royal Soc. Can. vol. III., sec. IV., pp. 6-7.

G. M. DAWSON. Photo. June 21, 1890.

LOOKING SOUTH-EASTWARD FROM CHOO-WHELS MOUNTAIN.

Showing Forest-clad Plateau at elevations of 4,000 to 5,000 feet.

It appears further that the peneplane at this time formed has never since been entirely obliterated, although it has passed through several stages of elevation and depression and has even been subjected to more or less deformation due to earth movements. At certain periods, it has been an area of deposition of strata and the theatre of great volcanic eruptions, the results of which have been, in some places, to level up previously formed irregularities in the surface, in others, to produce local elevation. At intervening times, the natural forces of waste have been engaged in reducing these superadded irregularities toward the old plane, but during the latter part of the Pliocene Tertiary, with the country standing at an elevation higher relatively to the sea than at present, the greatest erosive changes tending toward the destruction of the ancient plateau occurred. At this time, the main rivers cut deeply into its surface, while their smaller tributaries were actively engaged upon the edges of the intervening blocks of plateau, degrading these, and, in some cases, producing considerable widths of lower hilly country along the larger river-valleys. Its history.

In the general description of the Tertiary geology of the region (p. 66 B) and in the subsequent discussion of the various periods of erosion in connection with the auriferous drifts further particulars of the evolution of the surface features at different stages are given. Additional details, with an extension of the same inquiry over the entire area of the province of British Columbia, may be found in a paper elsewhere published.*

Thus our idea of the Interior Plateau as an entity must include some reference to its origin and former condition. But even as it exists at the present time, it is not unnatural to designate this region generally as a plateau, for, standing upon any point of sufficient elevation, the great lower valleys are entirely lost to view, while the higher tracts run together everywhere in the distances to form a nearly level horizon line, above which the rugged forms of some of the adjacent mountains may stand out. It was indeed the recognition of this fact which led to the conclusion that the many existing isolated areas of plateau are but parts of an originally single feature, and which induced an investigation of its cause and age. Further, it may be added that the several existing plateau areas, though differing considerably in elevation, do not do so materially as between adjacent parts. They do not represent blocks of country which have been bodily uplifted or depressed by faulting, but parts of a gently inclined and undulating surface, so that in such a view as that above referred to, the differences in height are not at all apparent. Present appearance of the plateau.

*Trans. Royal Soc. Can., vol. VIII., sect. IV., p. 3.

Slope of the Plateau.

Within the area of the Kamloops sheet, near its middle line, the normal level of the plateau may perhaps be described as declining northward from about 4500 feet to about 3500 feet, and it is very possible that the early Miocene drainage of the country took place in that direction. On this particular line, however, it will be observed that the volcanic accumulations of the vicinity of Savona Mountain and of the Arrowstone Hills, superadded during the later Miocene, to some extent interfere with the regularity of the main old pre-Miocene plateau. Further to the east, the high Sil-whoi′-a-kun Plateau forms another irregularity of the same kind.

Irregularities.

Toward the western edge of the map, it will be found (even in omitting from notice the deep but relatively modern valleys of the Fraser and Thompson) that the plateau does not regularly abut upon the Coast Ranges. Its regularity is here interfered with by several subordinate elevations, which are of two kinds—higher projecting ridges of the old rocks, and local volcanic accumulations of the Miocene period. The Marble Mountains and Pavilion Mountains are referable to the first category, the Clear Mountains to the second. But as the western edge of the plateau rises gradually toward the Coast Ranges, particularly in the south-western part of the area of the map, none of these stand out very boldly above it.

Different systems of valleys.

It will be understood from what has already been said, that the great valleys by which the Interior Plateau is now conspicuously trenched—those of the Fraser, the Thompson and their main tributaries—are relatively modern, being referable to the later part of the Pliocene Tertiary. This system of valleys is superposed upon an older one, believed to date from the earlier Pliocene, of which parts may still be traced meandering upon remaining blocks of the old plateau. Still older drainage systems, of which the streams took quite different courses, undoubtedly lie buried beneath the volcanic accumulations which are referred to the Miocene or middle Tertiary.

The bunch-grass country.

All the lower and larger valleys in the plateau region, up to an elevation of 3000 feet and sometimes considerably higher, are, in consequence of the dryness of their climate, either free from forest or dotted over with irregular groups of open wood or with single trees, of which *Pinus ponderosa* is the most characteristic. The terraces and slopes are naturally covered with bunch-grass *(Agropyrum tenerum)*. This is the case in the valleys of the Fraser and Thompson, also in the valleys of the North and South Thompson to the limits of the map, and in those of the Bonaparte as far as the Chasm, the Nicola, Junction Valley, Hat Creek nearly to a point abreast of Cairn Mountain,

G. M. Dawson.—Photo. Sept. 6, 1890.

STUMP LAKE, FROM THE SOUTH.
Showing open Grass Country of the Lower Valleys.

the lower part of Pavilion Creek, the valley of Loon Lake, Semlin Valley, the Deadman as far up as Gorge Creek, Copper Creek, Guichon Creek to the mouth of Meadow Creek, the lower part of Cherry Bluff Creek, Peterson Creek, Reservation Creek, the wide valley running south of Kamloops to Nicola Lake and the Upper Nicola River.

Tillable land.

In these lower valleys, nearly all the land available for agriculture is situated, and in most of them irrigation is necessary to produce crops. The open bunch-grass slopes adjacent to these valleys are always most extensive along their northern sides, and in some cases country of this character extends far beyond the immediate valley into lower hilly tracts of the adjacent plateau. This is notably the case in the vicinity of Ashcroft, in the hilly tract on both sides of the North Thompson near Kamloops, in the vicinity of Stump Lake, on both sides of the Upper Nicola valley, and on the western slope of the Pavilion Mountains.

Partially wooded country.

In the higher parts of all the main valleys above enumerated, and in those of very many of their tributaries, the country still continues to be open or but sparsely wooded, with an abundance of grass on the slopes or on the terraces and flats about the streams. Here, however, the bunch-grass is found only on the slopes most exposed to the sun, while various kinds of flat-leaved grasses, with wild peas, vetches and other species of herbaceous plants are more abundant elsewhere. A change of the same kind is indeed found to occur with increasing elevation in all parts of the country, so that, in climbing from almost any one of the lower valleys, the nearly treeless slopes are exchanged at a certain elevation for open woods, consisting of Douglas fir (*Pseudotsuga Douglasii*) or yellow pine (*Pinus ponderosa*). The width of this belt varies much with the exposure, and depends also largely upon the steepness of the slopes itself, but in the aggregate the area thus characterized is very considerable. Conditions of the same kind obtain over some of the lower parts of the plateaux themselves. This is especially the case on the Green Timber plateau, where open grassy country is interspersed with areas of forest, in this case largely composed of small black or bull pine (*P. Murrayana*), and in which innumerable small lakes, some of them saline, occur. The Bonaparte plateau, with open woods, somewhat resembles the last, while similar, though less considerable, areas of the same kind are found about Toon-kwa Lake to the south of Savona, near Uren's on the Upper Deadman River and along Meadow Creek. Many smaller patches of a like character might be enumerated.

Pastoral lands.

The various classes of country above described constitute the chief grazing grounds of the region, upon which large herds of cattle and

horses are maintained. The lower tracts are naturally the best winter ranges, and these it is now becoming customary to fence, in order to reserve them for winter feeding; while in many of the higher valleys, abounding in natural meadows, hay is now annually cut and stacked in the summer, in order to provide a reserve against the occurrence of an exceptionally severe winter.

The forest country.

Much the larger part of the plateau area is, however, covered with dense forests of trees of medium or small size, including, in order of abundance or nearly so, black pine (*P. Murrayana*), white spruce (*Picea Engelmanni*), Douglas fir (*Pseudotsuga Douglasii*) and balsam spruce (*Abies subalpina*). In such tracts, narrow irregular borders only along the banks of streams or swamps, produce any grass; few trails or practicable routes for horses are found, marshy spots are frequent and great regions of almost impassable "windfall" occur. For the last-mentioned impediment to travel, the recurrent fires are responsible. These in consequence of carelessness on the part of both whites and Indians have devastated great tracts. In some places where such fires have passed more than once, the woods have been locally almost completely removed, but the soil, being by the action of the fire itself much deteriorated, even then produced as a rule but a scanty growth of grass of indifferent quality. In other instances, an almost impenetrably dense crop of young trees springs up immediately. In the course of years, these dense forests of northern type will undoubtedly for the most part disappear, and although this will facilitate travel, and render the examination of all parts of the region much easier than it is now, it appears certain that no great concurrent advantage will result in regard to the extension of grazing grounds, while the supplies of the streams which now yield water for purposes of irrigation will be seriously impaired.

Alpine park land.

At or about an elevation of 5000 feet, the dense character of the woodland country above described begins to change. The forest, which is composed chiefly of black pine, white and balsam spruce, with (in the south-western part of the region) the white-barked pine, begins to open out. Without any marked decrease in the size of individual trees the forest covering becomes more sparse, and as somewhat greater heights are reached, the trees arrange themselves in separate clumps with grassy intervals. In many places park-like country of this kind is somewhat extensive. This is particularly the case between 5000 and 6000 feet on the Nicoamen Plateau and Lytton Mountains, in the Clear Mountain range and on the Sil-whoi'-a-kun Plateau. The Marble Mountains and higher parts of the Pavilion Mountains, are so bare of soil that such conditions are not

reproduced upon them, and the same is generally true of the Coast Ranges. In the Sil-whoi'-a-kun region, as the name itself denotes, this high open country was, within the memory of Indians still living, a home of the caribou—an animal now found no nearer than the uplands and mountains in the vicinity of the Clearwater branch of the North Thompson. The aggregate area of such alpine park land is not inconsiderable, and during a few months of summer it is always singularly attractive, watered by innumerable rills, and covered with gay alpine flowers. During that season, it is capable of affording nutritious pasturage to cattle, and although it has not yet been utilized for this purpose, there can be no doubt but that it will be so employed in the near future.

Timber limit.

The upper limit of the growth of any trees in an arboreal form, may be stated for the region as being about 7000 feet, and, at this height, the more hardy forms, last enumerated, survive only in the sheltered valleys. In regard to the upper limit of thick forest, it is pretty clear that this is defined by the amount of the snowfall. Above a certain height, varying somewhat with locality and exposure, the depth of the winter snow is so considerable that, if the forest became dense, the snow would not disappear from beneath its shade soon enough to enable any appreciable growth to occur. Thus any tendency to a thick growth is naturally checked, for only a certain number of trees, or clumps of trees, to a given area find the necessary conditions for permanent existence. A different cause must, however, be found for the sparsely wooded condition of the lower valleys, and this it appears is the absence of sufficient moisture. A limited number of trees, with their widely extended roots, practically absorb all the moisture which the soil is capable of yielding, and, so long as they exist, prevent the establishment of any new arboreal growth.

Causes of sparsely wooded tracts.

Part of the Coast Ranges included in the map.

On referring to any general map of British Columbia, it will be seen that the Kamloops sheet includes but a narrow selvage of the inland side of the Coast Ranges, or wide belt of mountainous country which runs parallel to the coast for the entire length of the province. This selvage consists in fact of but one of the component minor ranges of this complex of mountains, bounded to the east by the Fraser Valley and to the west by a somewhat important parallel depression which has not been explored, but which appears to be occupied by the head-waters of the Salmon River and Quoieek River. The axis of this range is granitic, while both its flanks consist largely of altered stratified rocks, often schistose or slaty but not true crystalline schists. Except in the greater importance of these stratified rocks here, this part of the Coast Ranges is, however, so far as known, identical in

its character and structure with the whole extent of the mountainous country in this vicinity and may thus be taken as typical of it.

From the valley of the Fraser, no adequate idea of the topography of the Coast Ranges can be formed, as the lower shoulders of the mountains preclude any general view of their higher parts. A fine view of one part of the range may be had from the line of the railway, between Lytton and Nicoamen, in ascending the Thompson valley ; but in order to obtain a just conception of its character, it must be seen from points along the east side of the Fraser of more than 5000 feet in height, or from some of its own summits.

Eastern front of the range.

The side of the range bordering the Fraser, is found to present a nearly uniform wall of mountain slopes to the river, and is composed of very steeply inclined high spurs of nearly similar form, each of which is separated from the next by a deep narrow gash, which may either be that of a small torrent or that of one of the main streams rising far back in the range. Above and behind these spurs, the mountains become more rugged in shape and show more bare rock, while here and there an apparently dominant peak stands notably above the rest and carries large patches of snow throughout the summer.

Its higher summits.

Such a view of the range may be gained from almost any of the mountains on the east side of the Fraser, but on ascending one of the peaks of the range itself to an elevation of 8000 feet or more, it is found that the points which seemed to dominate, as viewed from lower levels and from the eastward, owe this appearance chiefly to their proximity to the edge of the range. From such a peak, it will be observed that there is little regularity in the trend of the component mountain masses of the range, but that there is a very notable uniformity in the elevation of its higher points. It will be observed that a large number of these approximate in height to 8000 feet, while a few only, reach or slightly surpass 9000 feet ; that there are few instances of really dominant summits with lesser subsidiary mountains grouped around them, but that in widely extended views to the south, west, or north, the very numerous and closely set sharp summits run together to form a jagged, but in the main nearly level horizon line. To illustrate this point, it may be mentioned that, on one occasion, from Stein Mountain, looking over the crests of all the nearer mountains, the summit of Mount Baker, of the Cascade Range, more than a hundred miles distant, was clearly recognized as a markedly outstanding point, although its elevation is not much more than 10,000 feet.

Extent of snow.

In looking southward over these mountains after midsummer, about half the surface of their upper parts is still covered with snow, the

remainder showing bare gray, or rusty, and somewhat brownish rock. Some of the higher and more sheltered valleys remain deeply filled with snow throughout the year, and there are occasional small masses of glacier-ice upon a few of the heights at a considerable distance back from the Fraser valley.

Local diversity.

Although thus, in such a general view, almost monotonous from their similarity in height and from the repetition of wave like and pyramidal forms, the mountains are extremely rugged and diversified in detail, with cliffs and crags of varied and picturesque forms and sharp irregular crests running up from the subordinate ridges to the main summits. Amongst these, and in the higher parts of the valleys, the mountain goat (*Aplocerus montanus*) finds a secure retreat, in which it is very seldom disturbed by the hunter.

Character of valleys.

It will be noted on the map that the main streams draining these mountains rise far back to the westward, and that they show a tendency to flow in a direction nearly transverse to that of the range. In their lower parts, the valleys of these streams are usually mere cañons, or wild gorges, with exceedingly steep and high bordering slopes. A higher series of tributary valleys, though still deep, are wider in proportion to the size of the streams, with somewhat lighter slopes, often wooded, though occasionally interrupted by rock slides or by cliffs. About the heads of the valleys of this class, and in the case also of their many smaller tributaries, alpine valleys with an abundant fresh herbaceous growth and scattered clumps of lichened trees occur, and these generally terminate, either in cirque-like amphitheatres surrounded by cliffs, rock-slides and steep slopes of snow, or in narrow V-shaped gorges. A still higher series of cirques is also observed in some places, in which the surface is divided between rocks and snow, with here and there a small tarn or pool, and scarcely a trace of vegetation of any kind, but gray, solitary and alpine in their aspect.

Cause of general uniformity in height.

Reverting to what has been said of the great general uniformity in height of the majority of the culminating points and ridges of the Coast Ranges, the question naturally presents itself in what manner such uniformity has been brought about. It can have little if any connection with the original form and height of the elevated tract of the earth's crust out of which the existing ranges have been carved by a prolonged process of denudation ; nor is it peculiar to the mountains here particularly considered, for a similar condition has been noted elsewhere in many mountainous regions. Cases may occur in which the surface of a peneplane like that previously alluded to, or that of a plain of marine denudation, has, subsequent to the time of its formation, been thrust up to such heights as to admit of

the production of mountain ranges in the course of its degradation, but such cases must be rare.

Region of maximum denudation.

The suggestion is made that such uniformity in the higher points may depend fundamentally upon the greatly accelerated rate of denudation above a given plane of height in a mountain region. This plane would appear to be that limiting the existence of perennial snow. and below which the slopes are more or less continuously forest clad. It is well known that the continual presence of water during the summer, with the occurrence of frost almost every night, constitute peculiarly effective conditions of denudation. It has then only to be assumed that the progress of denudation in the partially snow covered regions is several or many times greater than below it, to account for the rapid disappearance of rock-masses above this height.

The general reduction of outstanding points in an entire region to the level at which maximum denudation ceases, must of course imply a considerable period of stability at a certain height and under given conditions; but it is precisely in those mountain regions which are not the newest geologically, that such effects are most marked. In the Coast Ranges of British Columbia, the great quantities of broken rock everywhere surrounding the actually highest summits shows the activity of the forces here adduced; for all such material, in addition to that carried away by the streams, must have accumulated since the close of the glacial period. The explanation here offered is a general one, but as it occurred to the writer in connection with the study of that part of the Coast Ranges included in the Kamloops sheet, it may appropriately be alluded to in connection with these mountains.

Facts bearing upon other points of the physical geography of the Kamloops sheet, such as the lakes, and the changes referable to action during the glacial period, are accorded mention in subsequent pages of this report.

Climate.

The climate of the region included in the Kamloops sheet is largely dependent on its orographic features. Both the annual and the diurnal range of temperature is great, while the precipitation is scanty. Even in that part of the Coast Ranges included in the area, the snowfall, though considerable, is in no way comparable to that which occurs in the western parts of the same mountainous belt. It is, in fact, as a result of this barrier between the Pacific and the Interior Plateau that the prevalent westerly* and moisture-bearing winds become desiccated before they reach the latter region.

*An examination of the stunted remnants of trees on the flat summit of Zakwaski Mountain, 6600 feet, indicated the prevalent direction of winds at that elevation to be from S. 75° W.

The climate of Kamloops itself, situated near the centre of the Interior Plateau region, at a height of 1150 feet, and thus illustrating that of one of the lower valleys, is represented in the following table, kindly furnished by the Director of the Meteorological Service. The amount of rainfall is unfortunately not included, but this is probably somewhat greater than at Spence's Bridge, where it is about ten inches in the year. Data for Kamloops

THE annual average of the mean highest, mean lowest, highest, lowest and mean temperature, mean daily and monthly ranges and per cent of clouded sky, derived from observation, 1877 to 1893, inclusive, at Kamloops, B.C.

—	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
Mean highest......	29·2	29·6	50·0	60·2	68·2	77·2	83·7	84·2	74·0	57·3	42·9	34·4	......
Mean lowest........	14·6	11·4	27·9	36·7	45·5	49 7	55·2	54·9	46·1	39·4	30·9	23·0	.. ...
Highest............	48·1	46·5	62·4	73·7	79·1	93·2	97·3	94·0	85·7	72·9	60·9	48·7	97·03
Lowest	-8·7	-10·3	9·6	28·0	33·1	39·8	48·7	48·7	55·2	24·7	10·5	-0·9	-10·03
Monthly mean....	21·9	20 5	38·9	48·4	56·7	63 5	69·1	69·0	60 0	47·1	36·3	28·9	46·69
Mean daily range.	14·6	18·2	22·1	23·5	22·9	27·5	28·5	29·3	27·9	17·9	12·0	11·4	21·03
Monthly range. ..	56·8	56·8	52·8	45·7	46·0	53·4	48·6	45·3	50·5	48·2	50·4	47·8	......
Clouded sky, p. c..	74·0	68·0	58·0	63·0	76·0	67·0	46·0	....	....	57·0	69·0	78·0	......

It is unnecessary to repeat the description of the causes and results of the flow of relatively warm and moist currents of air over such a barrier as that of the Coast Ranges, and their subsequent descent to a lower country, which have been given in my former reports on other parts of British Columbia.* Chinook effect.

It is sufficient to state that the effect is that variously known as the *foehn* or *Chinook*, now well understood and described in text-books of meteorology. The air, already dried in its passage over the range, is mechanically warmed in proportion to the amount of its descent, and is thus rendered still more susceptible of absorbing moisture and incapable of affording any rainfall. This effect is naturally most intense in the immediate lee of the mountain range, as is very clearly seen in this particular district. Standing upon some high point, as for instance, one of the summits of the Clear Mountains, the Coast Ranges may not infrequently be seen to be buried in clouds, which as they detach themselves and drift eastward are gradually absorbed, a clear sky obtaining over the western part of the plateau. New bodies

*Report of Progress, Geol. Surv. Can., 1879-80, pp. 76 B—78 B; Annual Report, Geol. Surv. Can., vol. III. (N.S.) p. 22 B.

of cloud, from which local showers fall, may often at the same time form about the higher parts of the plateau itself.

Distribution of rainfall.

A study of these conditions, with the aid of the contour-lines on the map, will show how it happens that the lower valleys and those nearest to the Coast Ranges are the most arid parts of the district, while the humidity of many of the higher parts of the plateau, particularly those situated to the eastward, is at the same time still considerable, enabling them to be the sources of perennial streams which may be employed in the irrigation of the lower and drier tracts.

Trees as an index of climate.

A complete meteorological survey of the region would undoubtedly supply numerically accurate proof of these conditions, but in the absence of such data, much may be gathered from an examination of the natural vegetation, and more particularly of that of the native trees. A number of observations on the heights attained by various plants will be found tabulated in one of the appendices to this report. It is of course impossible to say how far the limiting range in height is determined by temperature, and how far by humidity, the effect being in each case a resultant principally of these two causes; but in respect to the other resultant known generally as "climate," and particularly in regard to the bearing of climate on agriculture, the indications thus afforded are important.

Altituesd reached by several trees.

The Douglas fir (*Pseudotsuga Douglasii*), and the yellow pine (*Pinus ponderosa*), because of the facility with which they are recognized and observed, may be regarded as ready indexes of this kind, and an examination of the heights at which these trees were last seen in various parts of the region, will show that the upper limit of the first-named tree declines from the vicinity of the Clear Mountains to the eastward—a distance of some fifty miles—from about 5500 feet to 4500 feet, while the yellow pine similarly declines from about 5000 to about 3500 feet in the same distance. It may further be noted, that the white-barked pine (*Pinus albicaulis*) is practically confined in its range to the dry alpine country characteristic of the Nicoamen Plateau and the Clear Mountain Range, immediately to the east of the Coast Ranges, where, between levels of 5500 and 6000 feet, it is one of the most abundant and characteristic trees. The actual elevation observed in each particular place is largely governed by the subsidiary effect of the exposure or direction of the slope of the country, but this also has an equally marked effect on agricultural possibilities.

Peculiar climatic conditions.

Many local climatic effects, which are of considerable importance and interest in the districts in which they occur, are naturally found in a country with boldly marked physical features like this. Thus, in the upper part of the Botanie Valley, a place resorted to every year by

G. M. DAWSON.—Photo. Aug. 27, 1890.

NEAR PORCUPINE RIDGE. [5,900 feet.]
Showing high Alpine Plateau with Engelmann's Spruce.

the Indians at the season for digging edible roots, the vegetation is not only notably luxuriant, but unusually varied. The cedar (*Thuya occidentalis*), white pine (*Pinus monticola*) and devil's club (*Fatsia horrida*), all plants seldom met with in this region and rather characteristic of a damp climate, are found here; while at the same time there is a large extent of open slopes, and no such continuous thick forests as might be expected with the conditions for the growth of these plants. It appears, however, that as the result of causes not very well understood, the winter snowfall is here unusually great. The Indians say that it lies on the ground to the depth of three feet and that in particular winters it is much deeper.

Local winds.

Owing to similar local conditions, a strong up-river wind developes almost every afternoon in summer in the lower part of the Fraser Valley, while during the winter season a frigid down-river wind frequently prevails. Similar land and sea breezes blow through all the main valleys in the Coast Ranges,* but there is some evidence to show that these affect only the lower strata of the atmosphere. Thus, on one occasion, while upon the summit of Botanie Mountain (6620 feet) the afternoon was characterized by a light westerly air, while in the Fraser Valley at Lytton and even in the Botanie Valley immediately below, a violent southerly wind was blowing.

Limit of agriculture.

The upper limit of agriculture in the region depends principally upon the elevation at which killing night frosts occur during the summer months, or season of growth of the crops. Practical experience has shown that, in so far as wheat is concerned, this limit seldom exceeds 3000 feet above the sea-level, while it is often found to be at considerably lower levels in consequence of local circumstances. Barley and other more hardy crops may of course be grown at somewhat greater altitudes, but as a rule the surface of the plateau generally is much too high for agricultural occupation The highest areas upon which wheat is successfully grown occur near the wagon-road on the southern and western slopes of Pavilion Mountains and on the upper part of Hat Creek, the elevation being in the first case from 3500 to 4000 feet and in the second about 3500 feet. The highest farm upon the part of the Pavilion Mountains named, is situated a little above 4100 feet and here, though barley and oats may be grown successfully, wheat and potatoes are not profitable crops. It will be observed that all these places occupy sheltered positions near to the inner margin of the Coast Ranges, where, as already stated, the *foehn* effect is most notable.

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* Annual Report, Geol. Surv. Can., vol. III. (N.S.), p. 22 B.

Crops of the lower valleys.

In the lower valleys, such as those of the Fraser and Thompson, notwithstanding the occasional severity of the cold of winter, the summer heat is very great and nocturnal frosts are not known at this season. The extent of arable land in these valleys is not very considerable, but, with a proper supply of irrigation-water, many of the benches and slopes may be rendered exceedingly productive. Grapes, water-melons, musk-melons and tomatoes grow luxuriantly, and may be cultivated as field crops; fruit trees of all kinds flourish, and considerable quantities of beans for the local market are produced by Indian and Chinese cultivators. Where southward-facing slopes occur upon which water can be brought, it is certain that by terracing the surface, extensive vineyards might be established; and as it is a well known fact that the better qualities of light wines are produced near the northern limits of the vine, it appears possible that a not unimportant future may await the intelligent development of some parts of these valleys for this purpose.

Minimum temperatures at various heights.

As a general rule, it is found that the temperature of the atmosphere decreases in ascending to the amount of about one degree Fahrenheit in 300 feet. This, of course, applies to the mean temperature, while the lowest nocturnal temperature during the season of growth is the important one in limiting agriculture in this region. As throwing some light upon this question, the minimum readings, extracted from the meteorological observations kept during the progress of the explorations, have been tabulated in accordance with the elevations at which they were taken, for comparison with those registered simultaneously at the Kamloops meteorological station. The resulting tables appear as an appendix to this report.

Larger animals.

A note may be added respecting some of the larger animals of the region. As already stated, the caribou (*Rangifer Caribou*), once an inhabitant of the high plateau between the head-waters of the Deadman and Tranquille and the North Thompson still known to the Indians as Sil-whoi′-a-kun, is now locally extinct. The wapiti (*Cervus Canadensis*) was also not long ago abundant within the area of the Kamloops sheet, and weathered antlers of this animal may still be found, particularly in the hills near Stump Lake. Its resorts being in the open or lightly wooded tracts of the lower country, it was soon and easily exterminated by hunters. The black-tailed deer (*Cariacus macrotis*) is still abundant in the district, and the white-tailed deer (*Cariacus Virginianus*) is occasionally seen. Work done by beavers is frequently met with in all parts of the region, but the animal itself is now rare. The black bear (*Ursus Americanus*) is not uncommon, and the grizzly (*Ursus horribilis*) also occurs, particularly in the vicinity

of the Nicoamen Plateau. The mountain goat (*Aplocerus montanus*) is rather abundant in the higher parts of the Coast Ranges, and the big-horn, or Rocky Mountain sheep (*Ovis montana*), may often be seen in the mountains near Bridge River. Wolves (*Canis lupus*) are met with occasionally, and coyotes (*Canis latrans*) are in most years abundant below the main limit of the forest country. The rattlesnake inhabits only the lower and dry valleys, the greatest height at which it has been observed being 2520 feet, at Tso-tin Lake in the Pass Valley.

Natives.

The natives inhabiting the entire region covered by the map, belong to the Shuswap stock, and speak a single language with dialectic variations. Such particulars as I have been able to ascertain concerning them have been made the subject of a separate paper.*

THE MAP AND METHODS OF SURVEY.

Previous geological observations.

When the Geological Survey of Canada first extended its work to British Columbia in 1871, the geology of that province was practically unknown. In that year, lines of reconnaissance were carried through a part of the interior of the province by Dr. Selwyn and the late Mr. James Richardson. In succeeding years, up to and including 1875, Mr. Richardson's time was chiefly devoted to the examination of the Cretaceous coal-measures of the coast. In 1875, Dr. Selwyn again traversed the province on his way to the Peace River region, and the writer began his exploration of the interior region of British Columbia, which has been continued, though with some intermission, to the present time. Mr. A. Bowman is also to be credited with his map and report on the Cariboo mining district, published in 1889, and Mr. R. G. McConnell with his section across the Rocky Mountain ranges published in 1889, which has afforded valuable data for the eastern part of the province.

Reconnaissance work.

With the partial exception of the two last-named surveys, and some of those by Mr. Richardson in the Nanaimo and Comox coal fields, the work so far published has been almost entirely of the nature of reconnaissance, often extending over very large districts. This method of survey was rendered necessary by the demands for information on the structure of the country, and its prospective value in different parts, connected with the examination and discussion of various alternative railway routes, previous to the definite location of the Canadian Pacific railway on its present line.

*Trans. Royal Soc. Can., vol. IX., sec. II.

The map presented herewith, is therefore practically the first result of an attempt at a moderately detailed investigation and delineation of the geological features of any considerable area in British Columbia, and it is intended that further sheets of the same size and on the same general plan shall eventually be completed to cover possibly a large part of the province.

Earlier maps of the present district.

In 1877, the writer spent the entire season in the investigation, along its more early travelled lines of the southern part of the interior of the province, and a preliminary report and map were published in the volume for 1877-78. This map covered an area of about twenty-five thousand square miles. As the settlement of the country progressed, and after the railway had been completed, it became desirable to provide a more detailed and exact map, and Mr. A. Bowman consequently spent some time in adding to the topographical and geographical data for the same area. In 1887, a limited edition of a topographical map, including the later work, was printed, and in the following year the writer returned to the district with the purpose of revising and completing the geological data. The entire district was traversed in this year along a number of routes, special attention being given to the search for and examination of any sections which appeared to be likely to yield facts bearing on its general structure.

Adoption of 4-mile scale.

The result of this season's work was, however, to show that the scale of the map (eight miles to the inch) was too small to enable the geological intricacies of the region to be properly represented, and thus, in 1889 and 1890, the work was chiefly confined to the north-western quarter of the old map, of which the scale was doubled, making a map of the same size as the first, but covering only one-fourth of the original area. The increased scale, however, rendered necessary a complete redelineation of the geographical and topographical features, which part of the work has been skilfully carried out by Mr. J. McEvoy.

Want of geographical data.

Had a sufficiently accurate geographical outline been available for use in mapping the geological structure, much time would have been saved, and a better result would undoubtedly have been obtained. As it was, the line of railway, with some lines surveyed by the Dominion Lands Branch near it, were practically all those which could be depended upon. Elsewhere the geographical and geological work went on concurrently, and the interrelation of the geological facts was seldom clearly seen, till it became possible to lay these down on the geographical and topographical basis subsequently compiled in the office.

In order to complete, in any reasonable time, the map of a rugged mountainous country some 6400 square miles in area, with the means actually at disposal, it was necessary to strive after no greater accuracy than that sufficient for the scale in view. Thus, starting from the line of railway and the few other surveyed lines mentioned as fixed stations, a loose network of triangles was carried out between the natural points; a sufficient number of the more prominent elevations and peaks being ascended in turn and occupied as transit stations for that purpose by Mr. McEvoy. Where paced surveys had been made by Mr. Richardson in 1871, and by the writer in 1877, these were employed to fill in detail, but the greater part of the detailed topography depends upon track-surveys by Mr. McEvoy. Mode in which this has been supplied.

At each of the transit stations, and at many intermediate points, complete or partial profile sketches of the hills and mountains were made, upon which the vertical and horizontal angles were marked. Upon these, in conjunction with barometric observations, the heights given and the approximate contour-lines of the map depend. The barometric heights have generally been obtained by means of two or three good aneroids, checked by station readings regularly made at Kamloops; all the aneroids being directly compared from time to time with a mercurial barometer, and the readings being corrected by a scale of errors thus drawn up. The latitude of as many as possible of the transit stations was directly ascertained by sextant observations, within limits of error of a few seconds, and many intermediate points were also fixed in the same way.

As already noted, the geographical and geological work was carried out simultaneously. In fact, the writer, with his assistant, Mr. McEvoy, usually travelled together, the field party consisting besides of but three or four men, generally Indians or half-breeds, provided with a few pack-horses and riding animals. When high points were occupied as transit stations, these were at the same time employed to study, as far as possible from a distance, the distribution of the rock series. The geological observations were noted at the time on the topographical sketches, and subsequently checked on lines of traverse made in the surrounding country. Distant views of the kind referred to, were found to be particularly useful in affording information respecting the outlines of the basaltic plateaux, which would otherwise have cost much time and labour to define adequately. Method of field work.

From what has already been said of the general topography of the country, it will be understood that, as a whole, it is not an easy one to examine. While the larger valleys and lower tracts are generally open Difficulties encountered.

grass country, or are but lightly wooded, the higher plateaux and rough hills are frequently densely covered with forest, or encumbered with allen trees in such a manner as to render them almost impassable. Other considerable tracts are characterized by high rugged mountains, the elevations met with within the sheet ranging from about 400 feet above sea-level to over 9000.

Routes

The district is crossed by the main line of the Canadian Pacific railway, and is traversed besides by several roads and by a number of "trails" or travelled tracks; but large intervening blocks of country, which are seldom or never visited save by Indian hunters, have had to be explored for possible routes with considerable expenditure of time and labour; and although the length of route examined in the course of a day was seldom more than fifteen miles, and frequently much less because of physical obstacles met with, it was not often that the same camp was occupied or returned to on two consecutive nights.

It may be added, that the crushed and greatly weathered character of most of the rocks, together with the fact that in the Interior Plateau region they are often completely disguised by a crust of lichens, in most cases renders the recognition of rocks at any distance or from mere inspection almost impossible. The exposure must be actually reached and attacked with the hammer before its nature can be ascertained, and this is often a matter of difficulty, and one involving time and labour.

Degree of accuracy of the map.

It has been considered necessary to outline the methods of survey, as above, in order to indicate the degree of accuracy which may be supposed to attach to the results. Nearly all the routes followed, whether travelled trails or mere exploratory lines, are indicated on the map, this being the best way of showing where the geological features have actually been examined on the ground. A certain average standard of accuracy has been aimed at, and although at every point additional detail and more minute examination present themselves as desirable, each step in this direction increases many fold the time and labour necessary to the completion of a map. As it now stands, the map is offered as the best possible under the circumstances and on the scale adopted. It is believed that it will be of practical utility as an aid to the development of the mineral wealth of the district, and it is hoped that it may also be found to be a substantial contribution to the general geology of the exceedingly complex western part of the Cordillera of North America.

Geological isolation of British Columbia.

In regard to the systematic geology of British Columbia generally, it must be understood that our knowledge of this, so far as it goes, has been developed by slow degrees within the limits of the province itself,

beginning almost from first principles. This has been necessarily the case because of the absence of established general sections of the formations met with in any part of the length of the western portion of the Cordilleran belt. The early explorations of the geological pioneers in California, together with those of Prof. Whitney and his assistants, were scarcely of a sufficiently definite character to afford a basis of reference for any rocks below those of the Cretaceous system, while the systematic and detailed work done by the Fortieth Parallel Survey was almost entirely confined to the territories east of the Sierra Nevada— a region not structurally comparable with that to the west of this range, or with that which forms the greater part of the area of British Columbia. Within the past few years, however, and to some extent concurrently with the observations here reported on, geological work of a definite character has been undertaken in California by the United States Geological Survey, the results of which, in so far as they have been made known, tend to show a close relationship as to composition and structure between the rock-series there, and that of which the main features had already been developed in British Columbia. Reference is made in the sequel to such analogies and points of difference as have so far been brought to light in the course of this later work in California.

The Kamloops map.

With special reference to the Kamloops map-sheet, it may be added, that while the earlier and more extended examinations previously made of this and other parts of the province enabled its investigation to be begun with a general knowledge of the sequence and character of the formations, the more detailed section now presented has been practically worked out within the area of the sheet or in its immediate vicinity. Thus, while this section may be accepted as a type in the further progress of the geological mapping of neighbouring regions, no one is more conscious than the writer of its essentially provisional character in some respects.

ARRANGEMENT OF GEOLOGICAL MATTER.

Divisions of the report.

In the following pages, under the heading of *General Geology*, an outline of the main features relating to the several formations met with in the area of the Kamloops sheet is given, the evidence upon which each has been referred to its position in the geological scale is set out, and the relations of the several formations with others known in the western part of the continent is discussed. In this part of the report the formations are treated of successively, beginning with the Cambrian, which is the oldest recognized in the district.

elation to the ap.

The next division of the report is occupied by what may be termed *Descriptive Geology*, being a more detailed treatment and examination of the various principal sections afforded by the region, with local notes and facts relating to the geographical distribution and composition of the various rock-series. This necessarily occupies some considerable space. If it were possible to present a map drawn to a large scale, resulting from surveys and examinations so complete that the details of the composition and character of the rocks could be adequately represented upon it, much of the descriptive portion of the report might be omitted. In the actual circumstances this must, however, be relied upon to supplement the map. In other words, the descriptive matter required stands very nearly in inverse proportion to the completeness of the map which it is intended to accompany.

Classification of the older rocks.

With the knowledge now gained of the region included by the Kamloops sheet, it is generally easy to distinguish the Tertiary, Cretaceous and Plutonic rocks from each other and to separate these from the remaining rocks of the region. Where points of doubt are still found in these separations, they are chiefly due to imperfect exposures or to the incomplete examination of certain parts of the district. When, however, all these have been coloured in upon the map, the remaining mass of older rocks presents much greater difficulties. They may, in fact, be described as forming a 'complex,' of which the unravelling has so far proceeded but to a limited extent. The results of the work carried out on them appear to show that Cambrian, Carboniferous and Triassic strata are present, but they do not exclude the possibility of the existence of other formations which should intervene in the normal geological scale between these. It has been endeavoured, so far as our information concerning these basal rocks of the district allows, to separate them under the heads above named; but this separation is not yet so satisfactory as to admit of a strictly chronological treatment in every part of the region. Thus, in the pages which deal with the descriptive geology of these older rocks, the arrangement adopted is, almost necessarily, in part based on the districts in which they occur, though the developments believed to represent the Palæozoic rocks are in the main described first, while those rocks classed as a whole in the Triassic system are taken up subsequently.

Order partly geographical.

The typical development of the Câche Creek formation is first noticed, as being that which is best understood, while its less definitely known representatives, with other associated rocks, are next referred to. The rocks which have been excluded from it as Cambrian, in the north-east part of the sheet, are then described. Finally, the great mass of

strata which is referred to the Nicola (Triassic) formation is discussed, but with these it is found convenient to treat also of some rocks attributed to the Câche Creek formation, because of their regional proximity and the fact that they form parts of general sections, which it appears to be best to notice in each case as a whole.

Surface geology.

Both of the above mentioned sections of the Report relate, however, to what may be termed the 'solid geology' of the region only. A separate chapter is devoted exclusively to the 'surface geology,' or the examination and description of the superficial deposits or 'drift'; the character and distribution of which are largely due to action during the glacial epoch, assumed to mark the close of the Tertiary period proper. No recapitulation of this part of the report is included under the head of General Geology, and it may be regarded as constituting a separate essay, subsidiary to the first two divisions, although the facts disclosed by it are scarcely less important, particularly in their reference to the character and distribution of the gold-bearing gravels of the region.

Economic minerals.

In each of the three foregoing divisions of the Report, the bearing of the ascertained facts on economic questions relating to mineral deposits and mining is constantly alluded to; but in order to facilitate easy reference to all the economically important facts, so far as they are known, a fourth division of the Report is devoted to the summary treatment and enumeration of these, and to the details respecting various metalliferous districts which may prove to be of immediate importance to the prospector and miner.

THE TABLE OF FORMATIONS.

Arrangement of the Table.

As a key to the geological structure of the region, the subjoined synoptical table of the formations met with is given. From this all details have been eliminated, leaving only the main facts presented in the most concise form. In explanation of the table it may first be stated that it relates to what has been termed the 'solid geology' alone. The known unconformities or breaks in the series are indicated by the horizontal lines, but it must be understood that the value of these is very unequal, some representing long, while others represent comparatively short time-intervals, to an extent not fully ascertained. It will further be observed that in some cases local names have been adopted for the groups or formations. This has been done where it appeared to be necessary for the purpose of description, and particularly in cases where the precise limits, above or below, of a geological series are not known. The introduction of such new names

has, however, been minimized as far as possible. Thus it is believed to be sufficient to designate the upper and lower volcanic rocks of the Tertiary, simply as Upper and Lower Miocene of the Kamloops sheet, rather than to affix to each of these series of rocks some local name.

Thickness of rock-series.

It is further to be noted, that the maximum observed or estimated thickness is given in each case in the table. But it by no means follows that this always represents the actual maximum thickness, for in several cases there is reason to believe that the volume of strata, if accurately known, would much exceed the figures given. On the other hand, cases are not wanting in which a very small thickness of beds appears as the representative of what is elsewhere a very massive series. This is particularly found in the volcanic rocks of the Tertiary, where, in some instances a single flow of basalt spread over the surface of the older rocks is all there is to show for the more than 3000 feet elsewhere representing the Upper Miocene.

Again, in the case of the Cambrian rocks—the whole thickness of these actually known by sections in the Kamloops sheet is about 11,500 feet only, but in the sections on Adams Lake the volume of the upper member of the Cambrian alone is about 17,000 feet. These sections are so closely related to those of the Kamloops sheet that there can be little doubt that the entire thickness of the corresponding beds in it would be found to be nearly the same if fully displayed. It is somewhat different, however, in regard to the lower member of the Cambrian, for the thickness given under this head in the general section is derived from the section in the Selkirk Range, at a considerable distance, and it may very well be that, within the limits of the sheet, the actual thickness of this member is different—possibly less.

Aggregate thickness.

It will thus be apparent that the vast aggregate thickness of the rocks, amounting to 76,600 feet, need not be supposed to have ever been in any one place superposed as a single section; but it is very clear that, average the thicknesses determined as we may, we have an enormous volume of strata to reckon with in this part of the Cordilleran belt.

Great abundance of volcanic materials.

In a paper read before the British Association for the Advancement of Science in 1880,* the writer pointed out, as one of the most significant facts of the geology of the Cordilleran region, the recurrent accumulation there of great masses of volcanic materials at different stages of the geological scale. Subsequent investigations have served to confirm this indication and to increase its importance, and of this

* Geol. Mag., April and May numbers, 1881.

no better evidence can be given than the general section for the Kamloops region presented herewith. Further corroboration to the same effect, is also now coming in from various sources, as the investigation of the rocks of the Western States of the American Union is being proceeded with in the light of the comparatively recent recognition, for that region, of the existence of volcanic rocks older than those of the Tertiary.

Extravasation in Interior Plateau.

Assuming the section here given to be some index for the Interior Plateau region of British Columbia as a whole, an assumption consistent with the facts already known beyond the particular area of the Kamloops sheet, the writer believes it to be well within the limits of probability to estimate the volcanic materials from (and including) those of the Cambrian at about 20,000 feet in total thickness. In order to give definiteness to our ideas, it may be supposed, as a minimum, that the width of the belt characterized by this development of volcanic rocks is about one hundred miles. It follows, almost inevitably, that so vast an extravasation must have been accompanied by enormous subsidences, and, so far as can be ascertained, the main line of such subsidences must have corresponded generally with the present position of the Coast Ranges. Here, more than elsewhere, it would appear that thousands of feet of strata have been engulfed—forced down by superincumbent additions, or depressed by flexure below the surface till they reached the zone of granitic fusion. But the movement affecting the area of the Coast Ranges has not been continuously one of depression. Recurrent periods of elevation have resulted in the production, at more than one period, of a chain of mountains along this line, which has again more than once been broken down and carried away by denuding forces, till at the present day we find the existing mountains, low in comparison with some of those of the further interior, but consisting for the greater part of granitic rocks of deep-seated origin, with but scanty remnants of the older members of the Palæozoic series resting upon their flanks or remaining as infolds in their mass. Very often, and over large areas along the littoral of these ranges, the beds which rest directly upon the granites are of Triassic age; but from this it is not to be argued that the older formations have never existed there, for these may only have passed beyond recognition by entering as component parts into the subjacent granitic magma.

Probable subsidences in Coast Ranges.

	Period.	Special Names of Groups or Formations.	Character of the Rocks.	Approximate observed or estimated thickness in feet.	
Kainozoic.	*Early Pliocene?*	....	Conglomerates..........		
	Later Miocene.	....	Volcanic rocks, largely basalt..........	3,100	
		Tranquille beds.	Bedded tuffs..........	1,000	
	Earlier Miocene.	....	Volcanic rocks, largely porphyrites..........	5,300	9,400
	Ologocene.	*Coldwater group.*	Conglomerates and sandstones..........	5,000	5,000
Mesozoic.	*Earlier Cretaceous.*	*Queen Charlotte Islands formation (chiefly).*	Sandstones, conglomerates and argillites..........	7,000	7,000
	Triassic (and Lower Jurassic.)	*Nicola formation.*	Chiefly volcanic, some limestones and argillites, 7,500 to..........	13,500	13,500
Palæozoic.	*Upper Palæozoic* (Chiefly Carboniferous.)	*Câche Creek formation.*	IN WESTERN DISTRICT.		
			Upper part.—Marble Cañon limestone, with some volcanic rocks, argillites and quartzites..........	3,000	
			Lower part.—Argillites, quartzites and volcanic rocks with some limestone..........	6,500	
			IN EASTERN DISTRICT.		
			Campbell Creek beds (?) argillites and amphibolites, about..........	5,000	
			Argillites and grauwackes, limestones and volcanic rocks..........	7,500	12,500
	Lower Palæozoic. (Chiefly Cambrian.)	*Adams Lake series.*	Chiefly volcanic rocks with some arkose conglomerate. Thickness actually observed in Kamloops sheet, 9,500. Total thickness in adjacent Adams Lake section..........	17,100	
		Nisconlith Series.	Chiefly dark argillites. Thickness actually observed in Kamloops sheet, 2,000. Total thickness in Selkirk Mountains section..........	15,000	32,100
					79,500

GENERAL GEOLOGY.

In the following pages a brief general outline is given of the character and relations of the several formations under which the rocks of the district are classified.

Cambrian.

Evidence of Cambrian age here indirect.

It has of late years become evident, that rocks of the Cambrian system have a great extension in British Columbia, and are, at least in some places, developed in enormous thickness. No direct evidence of the age of the rocks classed as Cambrian within the area of the Kamloops sheet has, however, been obtained within the limits of the sheet, and their recognition here depends on several intermediate terms, by which they are connected with the great Cambrian series as developed in the corresponding part of the length of the Rocky Mountains proper. To make this clear, it will be necessary to enter into some short explanation of the facts. These rocks, with others believed to be Archæan, constitute a great part of the section examined in 1877 on the Shuswap Lakes, of which some account is given in the report for that year (p. 96 B et seq.), but respecting the age of which nothing could be said definitely at that time.

Rocks of Adams, Shuswap and Kootanie Lakes.

In 1888, an examination of the shores of Adams Lake, a body of water thirty-seven miles in length which lies to the west of the Great Shuswap Lake, afforded a better and less complicated section than had previously been obtained of rocks of the same old series. In 1889 similar rocks were again found and studied in the vicinity of Kootanie Lake. The lower or presumably Archæan series was there recognized, as well as a great thickness of overlying rocks, comprising black micaceous argillites, followed above by green and gray schists. The rocks here met with were evidently the same with those previously known on Shuswap and Adams lakes. In the report made upon the West Kootanie region, a general section was given, combining the results of work in this region with those obtained up to that time on the Shuswap and Adams lakes, and the several rock-series were distinguished under the provisional names of Shuswap (Archæan), Nisconlith and Adams Lake (Cambrian) series. It was also stated that "The gray and greenish schistose rocks [of Kootanie Lake] constituting the second group may, with confidence, be affirmed to be essentially composed of altered volcanic materials, and their present

schistose character may probably be regarded as in the main due to the enormous pressure to which they have been subjected during the movements of the earth's crust, which resulted in the uplift of the mountains of the region and the extrusion of the great masses of granite here everywhere found."*

It was further noted, in the same report, that although some evidence of this change dependent on dynamic metamorphism occurred in the Kootanie district itself, the best evidence upon this point had been obtained in the region between Adams and Shuswap Lakes and the North and South Thompson rivers; the allusion here being to part of the district adjacent to the eastern edge of the Kamloops sheet which had been examined in the previous year.

Similar rocks in the Selkirk Range.

Having arrived at this point, it became eminently desirable that a connection should be established between the older rocks of the Interior Plateau of British Columbia, the Gold Ranges and the western flanks of the Selkirk Ranges, and those to the eastward, in the Rocky Mountains proper, which had already been carefully examined along the Bow River Pass by Mr. R. G. McConnell, and reported on by him in 1887.† Thus in the autumn of 1890, an examination was made by the writer, on the line of the Canadian Pacific railway, across the whole width of the Selkirk Range. As a result of this examination of the intermediate region, it became possible to establish a fairly satisfactory correlation of the different developments of these older rocks, and of this a short review was given in a paper read in December, 1890, before the Geological Society of America, in which a comparative table was also presented of the rocks as found:—(1) On Kootanie and Adams Lakes.‡ (2) In the Selkirk Range on the line of Canadian Pacific railway, and (3) on the west side of the Rocky Mountains, as observed by Mr. McConnell.

These forming a connecting link.

The comparison thus instituted rendered it possible to correlate a large part of the rocks previously observed on the Kootanie, Shuswap and Adams lakes, as well as a part of those of the Interior Plateau of British Columbia, with the recognized Cambrian strata of the Rocky Mountains proper. It is, however, in the last-mentioned section alone, that any palæontological evidence is available by which to fix the pre-

*Annual Report, Geol. Surv. of Can., vol. IV. (N.S.), p. 30 B.

†Annual Report, Geol. Surv. of Can., vol. II. (N.S.)

‡Bull. Geol. Soc. Am., vol. II., pp. 165-176. In the table there given, as well as in that given in the report on the West Kootanie district above alluded to, the thickness of the Adams Lake series and its overlying beds was, by an error in the scale, made just one-half too small. This error is corrected in the table accompanying the present report.

cise age of the strata, and the correlation made between these rocks of the Rocky Mountains and those of the further western region, necessarily proceeds upon lithological and stratigraphical grounds.

In order, therefore, to justify the inclusion of a portion of the rocks met with in the area of the Kamloops sheet under the Cambrian, it becomes necessary to refer to the intermediate terms by means of which they are connected with those of the Rocky Mountain section. This will be most easily accomplished by reproducing, with such changes and corrections as have since become necessary, the comparative table which formed a part of the paper last referred to.

Before proceeding to speak particularly of the Cambrian rocks of the table, it must be noted that the beds included in the upper compartments of two of the three columns, are not known to be equivalent in any strict sense. They are so placed, only because they follow the rocks here described as Cambrian in ascending order. Thus these beds in column 1, very probably belong in large part to the Carboniferous formation, while the age of those occupying a corresponding position in column 3 is much greater, as known by their contained fossils. Table of Cambrian rocks.

In explanation of the table, the following general notes may be given, extracted wherever included between quotation marks, from the paper already referred to.*

The first column of the table represents the rocks met with in the western part of the Selkirk and Gold ranges, chiefly in the vicinity of Adams Lake, the Shuswap Lakes, and on Kootanie Lake. The lowest rocks in this column, the Archæan, were found best displayed on Kootanie Lake, and the thickness given is derived from the part of this system exposed there. The thickness and description of the overlying Cambrian divisions are practically those of the actual section measured on Adams Lake, or in its immediate vicinity.† These rocks run into the eastern part of the Interior Plateau of British Columbia, the section above the Fish-trap Rapid on the North Thompson (see p. 107B.) being directly connected along the strike of the rocks with Adams Lake. Column 1 of Table.

"The third column in the table represents Mr. McConnell's published section in the Rocky Mountains proper, in which certain horizons, ranging upward from the Lower Cambrian, are definitely fixed by fossils. It was found, in working out the section in this part of the Column 3 of Table.

* Bull. Geol. Soc. Am., vol. II., pp. 165-176.

† The thickness of these rocks previously given has been corrected, as already stated.

Provisional Comparative Table of Formations met with (1) in the eastern Border of the Interior Plateau of British Columbia (2) in the Selkirk Range, and (3) on the western Side of the adjacent Portion of the Rocky Mountain Range.

	1. Section on Kootanie and Adams lakes.		2. Section in the Selkirk range on line of Canadian Pacific Railway.		3. Section in the Rocky Mountains (west side of range; McConnell).	
	Feet. 6. Greenish and gray schists, with limestone.......... 4,000 5. Limestone or marble, with black, glossy argillites and some gray schists ... 5,000				*Feet.* *Halysites* beds. Dolomites and quartzites.................. 1,300 or more. *Graptolite*-bearing shales. Black fissile argillites, with some limestone 1,500	CAMBRO-SILURIAN AND SILURIAN.
Adams Lake series.	4. Chiefly greenish, with some gray schists............ 8,100 3. Chiefly gray, with some greenish schists.........17,100	*Selkirk series.*	Gray schists and gray quartzites, with some quartzose conglomerate and interbedded blackish argillites, the last chiefly toward the base...........25,000	*Castle Mountain group.*	Greenish and gray calc-schists and greenish and reddish shales and slates, with some dolomitic limestone......... 10,000 (probably).	CAMBRIAN.
Nisconlith series.	2. Black shaly or schistose argillite, with some limestone........... ... 1,000 or more.	*Nisconlith series.*	Blackish argillite-schists and phyllites, generally calcareous, with some beds of limestone and quartzite....... 15,000	*Bow River series.*	Dark argillites, with some quartzites and conglomerates, the latter particularly toward the summit. Base not seen...... . ... 10,000 or more.	CAMBRIAN.
Shuswap series.	1. Mica-schists, gneisses and marbles. .... 5,000 or more.	*Shuswap series.*	Gray gneissic rocks and coarse mica-schists .... 5,000 or more.			ARCHÆAN.

Rocky Mountains, that a considerable difference exists between the section of the eastern as compared with that of the western part of the range, the present width of which (whatever that originally occupied by the rocks composing it may have been) is about sixty miles only. The particular feature of this change which is interesting in the present connection, is that observed in the Castle Mountain (Cambrian and Cambro-Silurian) group, which although it is on the east essentially a limestone formation, is found on the west to consist in large part of greenish calc-schists and greenish and reddish shales and slates.* No granitic rocks or true crystalline schists are seen in any part of this section."

The section represented by the middle column in the table is that found along the line of the Canadian Pacific railway in the Selkirk Range. "It occupies, geographically, as it does in the table, a position intermediate between that of the eastern border of the Interior Plateau and that of the Rocky Mountains. In this, as in the section given in the first column, no horizons have yet been fixed palæontologically, and the position given to the rocks therefore depends principally on the comparison of the section with that known in the Rocky Mountains proper. It is probable, from the composition and condition of the rocks, that they may be found to hold fossils ; but in the meantime it is believed that the lithological resemblance of the formations to those met with in the Rocky Mountains, is in itself sufficient to enable some important general conclusions to be arrived at respecting the rocks of the Selkirk Range, while the analogy of the rocks of the Selkirks to those of the first section is also such as to afford some clue to the age of the formations represented in it." Column 2 of Table.

"*The Nisconlith Series.*—Overlying the basal holo crystalline (Archæan) series in the Selkirk section, is a mass of rocks of which the thickness is estimated at fifteen thousand feet. These are dark coloured and generally blackish argillite-schists and phyllites, representing various stages in alteration between true argillites and micaceous schists. The rocks are usually rather finely fissile, with glossy and sometimes wrinkled surfaces, but often with much minute yet visible mica on the division-planes. These planes are in some cases evidently due to cleavage, but are often true bedding-planes. The rocks are usually calcareous, and frequently hold thin layers of dark-bluish or black impure limestone, together with occasional layers of dark quartzite. The coloration is evidently due to carbonaceous matter, and pyrites crystals are very common in certain zones. The only notable Nisconlith Series.

*Annual Report, Geol. Surv. Can., vol. II. (N.S.), pp. 24 D, 25 D.

diversity met with in the otherwise homogeneous mass of rocks is found towards the base, where (at the lower end of Albert Cañon) a bed of pure blue-gray crystalline limestone thirty feet or more in thickness occurs, and a short distance still lower in the section, a series of beds of over one thousand feet in thickness, consisting chiefly of granular pale gray quartzites. The quartzites are sometimes flaggy and generally more or less micaceous, and are interbedded as well as overlain and underlain by blackish micaceous argillites and layers of coarsely micaceous schists."

"These rocks undoubtedly represent the Nisconlith series of the first column, of which no extended sections have yet been found in the Interior Plateau, while to the eastward they certainly correspond, in the main, with the Bow River series of the Rocky Mountains, for which a thickness of ten thousand feet was there ascertained, though the base of the series is never exposed in the Rocky Mountains."

Selkirk Series.

"*The Selkirk Series.*—Between the foregoing series and the next overlying mass of beds in the Selkirk section no distinct line of division, even of a lithological character, has been observed, there being, apparently, on the contrary, a considerable thickness of passage beds, in which the dark schists of the lower series alternate with gray glossy schists characteristic of the upper series. The estimated thickness of this overlying series is 25,000 feet; and of its rocks the higher central peaks of this part of the range, comprising Mounts Sir Donald, Macdonald, Tupper, Hermit, Cheops, Ross Peak and others, appear to be wholly composed. Lithologically, it consists of a great volume of gray schists and gray quartzites, which are occasionally somewhat dolomitic. The quartzites probably preponderate, and vary in colour from nearly white to gray and greenish-gray, being seldom dark in tint. They often, however, weather to pale brownish colours and pass into coarse grits and fine-grained conglomerates; and these grits and conglomerates have become more or less schistose in structure as a result of pressure, which has also led to the development in them of much fine silvery mica. The schists vary in colour from pale neutral-gray to greenish-gray, and from dull to silvery and lustrous, being in many cases apparently true sericite-schists."

Representatives elsewhere.

These rocks undoubtedly represent, at least in a general way, those of the Castle Mountain group of the Rocky Mountain section, to the eastward. For this group Mr. McConnell ascertained a minimum thickness of 7700 feet, but found reason to believe that its total volume in the western part of the range approached 10,000 feet. They likewise also correspond, in the main, with the rocks previously named

the Adams Lake series, differing from them chiefly in the great development of quartzites and quartzose conglomerates; though the discovery of some thickness of precisely similar quartz conglomerates in rocks of the Adams Lake series, near their typical locality (see p. 108 B) tends to bridge over this difference. Under the circumstances, in 1890, it was thought best to name the series met with in the Selkirk Range the Selkirk series, rather than to affirm a precise equivalency of these rocks either with those of the Adams Lake or Castle Mountain series. In regard to this comparison with the last-mentioned series, "the line indicated between this and the underlying (Nisconlith) series in the Selkirks is based entirely on general lithological differences, while there is every reason to believe that a plane of division drawn to correspond with that between the Castle Mountain and Bow River series in the Rocky Mountains would lie several thousand feet above the recognized summit of the Nisconlith series in the Selkirks. In the Rocky Mountains, the Lower Cambrian (*Olenellus*) fauna is known to be common to the lower part of the Castle Mountain and upper part of the Bow River series; * the separation being there made at the base of the distinctly calcareous upper part of the Cambrian, while certain rather characteristic quartz-conglomerates observed in the upper part of the Bow River series of the Rocky Mountains are paralleled by similar conglomerates which abound in the upper series of the Selkirks. No unconformity has been observed between the upper and the lower masses of strata in either place."

Relations to Olenellus fauna.

"Though in the Selkirk section the lower of the two great series which have been described resembles the Nisconlith of the Interior Plateau so closely as to warrant extending the same name to it, the fact that the overlying member of the section differs considerably from the Adams Lake series of the Interior Plateau, while on the other side it probably represents not only the whole Castle Mountain group but also the upper part of the Bow River series of the Rocky Mountains, renders necessary the application to it of a provisional distinctive name. It is therefore proposed to refer to this rock-mass as the *Selkirk Series.*"

Selkirk and Adams Lake Series.

It is very probable, however, that it may eventually be found possible without inaccuracy, and therefore desirable, to unite at least the Adams Lake and Selkirk series under one of these names.

Regarded as a whole, we find reason to believe that the Selkirk and Nisconlith series of the Selkirk Range, and the Adams Lake and Nisconlith series, further to the westward, constitute local representatives

Great Cambrian formation.

* This fauna is known to characterize several thousand feet o the Castle Mountain series, and has been found as well about 3000 feet down in the upper part of the Bow River series.

of a great Cambrian formation, with an aggregate thickness in both cases of about 25,000 feet. This formation (by analogy with the Rocky Mountain section) includes the lower part of the Cambro-Silurian at its summit and extends, without stratigraphical break, down to, and far beneath, a horizon at which the *Olenellus* or Lower Cambrian fauna has been found.

In the paper from which the above extracts have been made, the following statement was given respecting the changed lithological character of these Cambrian rocks when followed from east to west across the component ranges of this part of the Cordillera :—

Change in lithological character.

"The comparatively pure limestones of which the Cambrian of the eastern part of the Rocky Mountains is composed are replaced in the western part of that range by rocks largely clastic in origin. This change in lithological character appears to continue, and to become still more marked and to be accompanied by increasing thickness in the Selkirk Range. Much of the clastic material is siliceous, and the introduction of an increased proportion of such material may be explained by considering it as a result of approach to the shore-line of Archæan rocks on the west. While the principal development of contemporaneous volcanic products, whether in the Palæozoic, Mesozoic or Tertiary, is confined to a region west of the local Archæan axis, the writer is inclined to believe that a portion of the remarkable difference found to occur in the western extension of the Cambrian, may be due to the inclusion in its rocks, on this side, of volcanic ash deposits or other fine-grained volcanic materials, of which the composition was such as to favour the subsequent production of sericitic or sericite-like schists."

Subsequent investigations appear fully to sustain the view thus advanced, showing as they do that in the rocks representing the Selkirk series in the vicinity of Adams and Shuswap lakes, the preponderance of quartzose clastic material is not maintained, but that green and gray schists which can be traced into diabases, diabase-agglomerates and other rocks of volcanic origin, form the great bulk of these rocks.

Introduction of volcanic material.

Thus it would appear, that while the massive limestones of the Castle Mountain series were in course of deposition in the region now represented by the eastern slopes of the Rocky Mountain Range, the calcareous materials become largely intermixed with volcanic detritus and arkose matter further to the west, producing under metamorphism the great mass of calc-schists found in the western parts of that range. In the Selkirk region, local granitic and gneissic shores

supplied great quantities of coarse sediments, while volcanic ash or other material resulting from contemporaneous volcanic action became to a still greater extent a constituent of the rocks. Still further to the west, in the vicinity of the region now occupied by the Gold Ranges, and also apparently to the southward about Kootanie Lake, massive volcanic rocks became entirely preponderant at this time; the quartzose and arkose constituents are sparingly represented and pure limestones are no longer found. Rocks still represented by massive diabases and by diabase-agglomerates, where not affected by great dynamic alteration, are now found in the form of the green and gray schists of the Adams Lake series, and can actually be traced into connection with their massive originals to the west of the flanks of the Gold Ranges. Even here, however, the argillites and limestones of the Nisconlith series continue as the lower number of the Cambrian, representing a period antecedent to that at which the great and evidently long-continued volcanic eruptions of the later Cambrian occurred.

Foliated and massive volcanic rocks.

The establishment, by observations in the field, of the fact of the passage of the green and gray schists of Adams and Shuswap lakes into the massive volcanic rocks, has afforded the key to the relations of the rocks of the Interior Plateau region with those of the Gold and Selkirk mountains. Recent observations made in different parts of the world, and particularly the microscopical investigation of certain schistose rocks, have already established the fact that such schists may be produced from old massive volcanic products by means of dynamic metamorphism; but without actual proof of the occurrence of so marked a change in the character of the rocks in this particular region, observations such as those referred to could be accepted only as affording a probable explanation of the conditions here met with. It has been found possible to trace out the change from a massive to a schistose character on the ground and in the large scale. The most direct connection established between the green and gray schists of Adams Lake and the non-schistose greenstones, is that by way of the Cin-max Valley and the lower part of the valley of Louis Creek. From the glossy chloritic sericitic and nacreous schists of the vicinity of Skwa-am Bay, on Adams Lake, following the general strike of the rocks westward, a gradual transition may be found to the more or less distinctly schistose diabases of the lower few miles of Louis Creek, and from these to the scarcely schistose diabases and felspathic rocks of the east side of the North Thompson above the mouth of Louis Creek.

Change traced in the field.

Foliation and measurements of thickness.

As the foliation of the schists is thus due to pressure rather than to any originally bedded structure, it may reasonably be questioned whether the thickness of such formations as the Adams Lake series

can be ascertained from observations of the dip of the schists as they exist at present. It must be admitted that this consideration introduces a considerable element of doubt, and in some places it is even quite apparent that the foliation cuts planes representing original bedding at an angle. On the whole, however, with regard to the schistose rocks of Adams Lake, Kootanie Lake and the Selkirks generally, I am inclined to believe, that there is usually a coincidence between the foliation and bedding such as to render estimates of thickness of the kind alluded to fairly trustworthy. The fact that alternations in character of material occur in layers parallel to the foliation, favours the belief, while on Adams Lake, for instance, the difference observed between the generally gray schists of the lower part of the formation and the generally green schists of the upper, shows that there is no bold overturn and repetition of the whole mass of these rocks. It therefore only remains possible, that portions of the same part of the original series of beds may have been locally folded together and compressed in such a manner as to involve a partial repetition of beds. But where this may occur, any increase of thickness accruing is probably more than compensated for by a general attenuation of other parts of the formation which must have resulted from the extreme degree of pressure to which the beds as a whole have been subjected. If this view be correct, it follows that while some undue prominence, which it is impossible to eliminate, may be given to certain classes of rocks in the section, the aggregate thickness and general character of the section as a whole has been little affected.

Area of Cambrian as mapped.

Reverting to the particular area of Cambrian rocks outlined upon the Kamloops sheet, in the vicinity of the North Thompson; it must be confessed that it is not without some hesitation the attempt to define these rocks has been made. Their limit may be said to be drawn entirely on lithological grounds of difference observed between them and the strata adjacent, which are referred to the Câche Creek formation. The area coloured as Cambrian, however, is certainly coextensive, particularly in its southern part, with one of metamorphism much greater than that ordinarily found in the same region, and should it be found necessary in the light of further investigation to change the position of the line, it has, as now drawn, at least a certain value in differentiating this metamorphic area.

It is by no means improbable, as elsewhere stated (p. 109 B), that a considerable tract to the west of the North Thompson and north of Whitewood Creek, should be included with the rocks just referred to, but the balance of the evidence at present appears to me to be against this.

Reference must also be made to the possible existence of Cambrian rocks in the much disturbed and altered western edge of the Palæozoic series in the vicinity of the Coast Ranges, as mentioned on page 43 B.

Newer Palæozoic Rocks—Chiefly Carboniferous.

As the result of his own investigations and those of Mr. James Richardson in British Columbia, concurrently made in 1871, Dr. Selwyn was led to propose two groups (constituting the fourth and fifth groups of his preliminary general section) with the names of Upper Câche Creek and Lower Câche Creek respectively, under which he included a large part of the older rocks of the interior of the province. The Upper Câche Creek group embraced the massive limestones of Marble Cañon and of the Marble Mountains, with some associated "red and green shale, and epidotic and chloritic rocks, with others which closely resemble rocks of the Quebec group in the Eastern townships of Canada." The Lower Câche Creek group was made to include the cherty quartzites, argillites, greenstones, serpentines and associated limestones found to occur along the Thompson and Bonaparte valleys in the vicinity of the main wagon-road.* It was at this time suggested, because of the occurrence of a foraminifer recognized as of the type of *Loftusia* in the Marble Cañon limestones, that the Upper Câche Creek group was of Eocene or Cretaceous age, while the Lower Câche Creek group, on the evidence of the fossils examined by Mr. Billings, was known to occupy a position somewhere between the base of the Devonian and the summit of the Permian. History of the Câche Creek formation.

In reporting on a portion of the northern part of the interior of British Columbia in 1875, the writer assigned some of the rocks there met with to the Lower Câche Creek group, on lithological grounds alone, for no fossils were discovered in them.† In the following year, as the result of further and more extended work in the same northern region, the peculiarly Carboniferous fossil *Fusulina* was found to be abundant in the massive limestones of Stuart Lake, and these limestones with certain quartzites, argillites and green schistose rocks, were together classed under the Lower Câche Creek group; while their relations with rocks of the southern part of Vancouver Island and with those of a portion of the Rocky Mountain range, were also pointed out.‡ Northern representatives. Discovery of Fusulina.

* Report of Progress, Geol. Surv. Can., 1871-73, pp. 60-62.

† Report of Progress, Geol. Surv. Can., 1875-76, pp. 247-250.

‡ Report of Progress, Geol. Surv. Can., 1876-77, pp. 55, 89.

Consolidation of the Upper and Lower Câche Creek groups.

It will be observed that no rocks referable to the Upper Câche Creek group had been found during the explorations of 1875 and 1876, and when in 1877 a further and more detailed examination was made by the writer of the southern part of the interior of the province, upon which the original classification had been founded, the conclusion was arrived at that the so-called upper and lower groups are not strictly separable on stratigraphical or lithological grounds, while *Fusulina* was found to occur in association with the massive limestones of Marble Cañon as well as in the limestones of the lower group. In the report on the work of the season, the whole of the rocks previously placed in these two groups were referred to under the name of the Câche Creek series,* and further investigations have since served to bear out this consolidation of groups. Thus in the present report, as in that last referred to, the Câche Creek series or formation must be understood to embrace the rocks originally included in the Lower and Upper Câche Creek groups. There can indeed now, I think, be no doubt that the Marble Cañon limestones, which constituted the greater part of the Upper Câche Creek group, are in fact the higher member of the formation, and between these and the underlying rocks it may eventually become convenient to draw a line of division. But important beds of limestone also occur in the lower part of the formation; there is a stratigraphical and lithological interlocking between both parts, and the palæontological evidence, so far as it goes, indicates the reference of both parts to the Carboniferous.

Interlocking of characters.

Relations of Câche Creek and Boston Bar groups.

It must further be explained that, in mapping the Palæozoic rocks of the area here described, it has been found practically impossible to separate the rocks originally spoken of as the Anderson River and Boston Bar group† from those of the Câche Creek formation. Dr. Selwyn was, at the time he proposed this name, unable to assign any age to these rocks, but the order of the group in his report shows that it was understood to lie below the Câche Creek formation. This reference proves to be a correct one, for it can now scarcely be questioned that these rocks either underlie the greater part of the rocks classed as the Lower Câche Creek group, or correspond in part with the lower portion of that group. But while upon the single line of route originally examined, these rocks are widely separated by other groups from those of the Câche Creek formation, the two series have since, in different localities, been traced into connection, and in such places no means have been found of defining a line between these rocks. Some details on this point are given later. (p. 43 B.)

* Report of Progress, Geol. Surv. Can., 1877-78, p. 169 B.

† Report of Progress, Geol. Surv. Can., 1871-72, p. 62.

The Câche Creek formation, as shown on the present map and as now understood, must therefore be regarded as including a very thick series of Palæozoic rocks, of which the greater part is definitely referable to the Carboniferous period by means of its fossils, but of which it is scarcely probable that the upper and lower limits agree precisely with those of the typical Carboniferous. It may very possibly be found at the base, particularly, to transgress these limits and to include beds older than those of that system. Câche Creek formation defined.

In attempting a brief general description of this formation, it must in the first place be observed that the extremely broken and disturbed character of its rocks, almost everywhere renders it next to impossible to learn much about their attitude or sequence in any one locality. It is very generally impossible to determine whether the dip of the beds is normal or has been overturned. It is thus only by following the general association of the rocks from place to place and by piecing together facts observed at many different places that it becomes practicable to outline the salient features of the whole. Its shattered character.

The western part of the Kamloops sheet, between the Thompson and Bonaparte rivers on one side and the Fraser on the other, is the typical area for the Câche Creek formation, and the most definite feature which can be traced throughout, is the belt of massive limestones already several times referred to. Beginning to the north in the Marble Mountains, these gray and whitish limestones, sometimes marbles, are continued in the Pavilion Mountains, cross Marble Cañon, and after an interval in which they are concealed by Tertiary rocks, reappear in the western part of the Cornwall Hills, extending southwards to White Mountain and to Blue Earth Creek. Further south the Tertiary volcanic rocks are continuously spread across their line of strike. The marble Cañon limestones.

Practically the entire mass of the Marble Mountain range is composed of these limestones, as well as the whole eastern part of the Pavilion Mountains. They include comparatively insignificant intercalations of argillite, cherty quartzite and materials of volcanic origin. Further south, in the region to the east of Hat Creek, such materials become more abundant and form thick beds among the limestones, particularly the cherty quartzites and the green stones. In this region it is probable that the lower part of the great limestone series is most prominently displayed, and that higher beds are more characteristic in the north, particularly in the Marble and Pavilion Mountains. The earlier stages of the great period of limestone deposition appears to have been marked by frequent interruptions, during which argillaceous and Character of the rocks.

volcanic products were laid down; while in its later stages, the deposition of limestone must have been almost unbroken. The interlocking of the different classes of materials is such, however, as to show the close connection which obtains between the Marble Cañon limestones and the lower parts of the Câche Creek formation.

A great syncline.

The limestone belt above described, has, within the limits of the map, a length of above sixty miles. There can now be no doubt that this represents a great syncline, upon both sides of which the older members of the Câche Creek formation are displayed; but superimposed upon this general structure are very numerous smaller folds, which generally run in more or less exact parellelism with it, but often in varied directions. The limestone has thus been, as it were, heaped together by repeated folding, in such a manner that it occupies a width much greater than that which can possibly be due to its thickness, with the high dips which are usually found. Similar complex folding affects the underlying rocks of the formation, and it is due to this fact that it is almost impossible to obtain any good estimate of its total thickness or of that of its parts. This folding is not generally of the tightly compressed and linearly direct kind met with in, and near, the mountains of the Coast Ranges, but is just sufficiently irregular to make it very difficult to follow. Occasional instances are also found—as for example on the upper part of Jack's Creek, between the Thompson and Hat Creek and in Glen Hart—where the rocks rest at very low angles; but these are in immediate contact with others in which the same beds are found to be nearly vertical.

Minor irregularities.

Lower members of the Câche Creek.

In speaking of the lower part of the Câche Creek formation, it will be convenient to refer first to the rocks on the east side of the main syncline, near the Thompson and Bonaparte; next to those lying to the west of the syncline, and last to those in the neighbourhood of the North Thompson and in the eastern part of the map generally.

Along the Thompson and Bonaparte, these lower rocks characterize a belt of country some forty-five miles in length. They consist of cherty quartzites, volcanic materials, argillites and limestones about in the relative order of importance in which these are named.

The 'cherty quartzites.'

The rocks which are for the sake of brevity spoken of throughout as 'cherty quartzites,' are of a somewhat peculiar character. They generally occur in well defined beds of a few inches only in thickness, and often form great masses of strata. They are very fine grained, resembling hornstone or chert, usually gray in colour, passing to black in one direction and to yellow-gray and nearly white in the other, but occasionally greenish-gray. Almost every where they are traversed by

innumerable veinlets and threads of white quartz. The bedding planes are often black and lustrous, and black glossy argillite-schist is frequently associated with them. These rocks have evidently been silicified subsequent to their deposition, but perhaps very soon after, for it is pretty clear that they were much in their present condition before the main period of disturbance by which the formation has been affected. Their microscopic structure throws very little light on their original character, but they have in all probability been laid down as argillites or silts. It is worthy of remark that they closely resemble in their character cherty or hornstone-like rocks found in different parts of the world in association with contemporaneous volcanic beds, affording ground for the belief that their condition may be connected with the circumstances of volcanic action.

True cherts.

It may be mentioned here that cherty beds, which may be of a different character, are not infrequently found in the limestones of all parts of the formation. These are often lenticular, and it is quite probable that many or all of them may represent original siliceous concretions of the nature of flint.

Rocks of volcanic origin.

The volcanic materials comprise contemporaneous effusive rocks, agglomerates or breccias and ash rocks or tuffs. The effusive rocks generally vary in colour from dark gray-green to green. They are usually rather fine-grained, and on microscopic examination are found for the most part to be very much decomposed diabases in composition. The coarsely porphyritic and uralitic diabases, so abundant in some parts of the Nicola formation, were scarcely seen. The agglomerates are made up in the main of fragments of the same character. The ash rocks and tuffs are often gray, but sometimes green, and when fine-grained it is difficult to separate them by the eye from the traps proper. Where they have been locally subjected to great pressure, the effusive rocks tend to pass into green schists, the agglomerates into rough gray schists, and the ash-rocks into gray speckled schists, in which the constituent particles are often drawn out into linear forms.

Serpentines.

With the volcanic rocks, the serpentines, which form a characteristic feature in this lower part of the formation, must be included. They are often seen to be closely associated with the agglomerates and decomposed diabases, and have evidently resulted from the alteration of some highly basic volcanic rock.

Argillites.

The argillites are generally hard and dark coloured, ranging from black to gray. They are often schistose, and sometimes show more or less slaty cleavage. In some places they are largely siliceous, and

evince a tendency to pass into the cherty quartzites. In the black varieties, graphitic or anthracitic carbon appears to be present.

Fusuline limestones.

The limestones found in the lower part of the formation, to the east of the main syncline, are seldom more than a few hundred feet in thickness and often much less. They frequently prove on microscopic examination to be composed chiefly of crinoidal debris, but often contain *Fusulinæ* and other foraminifera, as well as fragments of polyzoa and molluscs.

Rocks east of main syncline.

The cherty quartzites and argillites appear to constitute the bulk of the lowest part of the formation as displayed in this region, while volcanic rocks with associated limestones preponderate higher in the series, in that part of it which approaches the base of the Marble Cañon limestones previously described. The volcanic rocks, with limestone, occupy a considerable area near Cattle Valley, McLean Lake and Medicine Creek.

West of main syncline.

To the west of the main limestone syncline, the lower rocks of the Câche Creek formation come to the surface in the Edge Hills and their vicinity and in the western part of the Pavilion Mountains and Mount Martley. In their general character the beds here represented are much like those on the east side of the syncline. Argillites, generally schistose, are somewhat more abundant, and the typical cherty quartzites are not quite so well represented. The intercalated limestones appear to be somewhat less important, while rocks composed of volcanic materials are not found immediately beneath the massive limestones in so great volume as before, but appear to be rather more important at a somewhat lower horizon, which crosses the lower part of Pavilion Creek and is found with identical characters along the Fraser above Leon Creek. As a whole, the rocks are somewhat more altered than before. The argillites are more distinctly schistose, and the limestones are more often crystalline and marble-like.

Development west of Fraser

Further to the south, and west of the Fraser, rocks of the same character, and believed to be of the same age, are found in the vicinity of the town of Lillooet, extending along their strike to In-tl-pam Creek, and again seen on In-koi-ko Creek. They consist here of schistose and slaty argillites, cherty quartzites, well bedded decomposed diabase-tuffs and serpentines. These being included in the eastern strict folds of the Coast Ranges, are all somewhat more notably schistose than elsewhere, but show no other important points of difference.

Somewhat further back from the line of the Fraser, on Cayoosh Creek, Texas Creek and in the higher parts of the Askom Mountain, as elsewhere described in greater detail, the rocks become indistinguishable

in character from those of the Boston Bar series of the original (1871) scheme. On the assumption that these last-mentioned rocks might be of Cambrian age, an attempt was made to define a line which would separate them from those referred to the Câche Creek formation, but it proved to be impossible to draw any such line to accord with the facts, and the points of difference successively relied upon have broken down under investigation. The only notable and easily observed difference, is one dependent on the more schistose and slaty character of the rocks, which gives to them when examined in the field, a different general aspect. But this difference manifestly depends on the amount of compression to which the rocks have been subjected as infolds in the granitic masses of the Coast Ranges. It is in fact an extreme stage in the transition of which the earlier steps have already been referred to. Fundamentally the composition of these rocks, as well as that of the Boston Bar rocks in their typical locality, further south, is the same with that of the lower part of the Câche Creek formation on the Bonaparte and Thompson. Argillites, altered diabases, ash rocks (though now often passing into chloritic and epidotic schists and porphyroids), and limestones are equally present in both. Cherty quartzites are much less abundant in the Boston Bar rocks, but they are still to be found, and it will be remembered that the present character of these rocks is probably an adventitious and subsequent one. Even the serpentines may be represented by the talcose rocks which occur in some parts of the Boston Bar series.

Attempts to separate Câche Creek and Boston Bar rocks.

It is true that the present appearance of the Boston Bar rocks and their representatives within the Kamloops sheet is much like that of the lower rocks of the Cambrian, as found for instance in the section near Fish-trap Rapid. (p. 107 B.) This indeed led to the attempt to correlate the Boston Bar rocks with that formation; but against this theory, it may be remarked that the great superior thickness of volcanic materials characteristic of the upper part of the Cambrian in the section near Fish-trap Rapid and elsewhere, is not found in association with these rocks in the Coast Ranges, while the state and mode of alteration of the other rocks may well be accounted for by local causes, and would have affected equally any rocks similar in composition which existed there prior to the great period of folding and uplift of the Coast Ranges.

Resemblance of Boston Bar rocks to Cambrian.

No palæontological evidence is available for the rocks of the Boston Bar series, and as already explained, no attempt is made in this region to draw any hard and fast line as that of the base of the

No fossils found.

Câche Creek formation. It is quite possible that some part of these rocks may belong to horizons much lower than that of the Carboniferous, but in the present state of knowledge there appears to be no escape from the decision to unite them, at least provisionally, with the Câche Creek formation.

Auriferous character.

One point of particular interest with respect to the schistose and slaty rocks of the Boston Bar series and their representatives in the area of the present map, is their auriferous character. This feature is returned to on a subsequent page.

Rocks near North Thompson.

Turning now to the rocks of the Câche Creek formation, which are shown on the map to occur in the vicinity of the North Thompson— These rocks are found, on the lower part of that river, to be associated with limestones known by their fossils to be of Carboniferous age, but they are widely separated from their representatives in the western part of the map, between them and which no single connecting link exists within the area here reported on. Thus, besides the scanty palæontological evidence, we have only lithological characters upon which to rely. We find here a great series of argillites, often highly siliceous (but seldom with the hornstone-like characters of the typical cherty quartzites), with limestones, grauwacke sandstones, conglomerates and contemporaneous greenstones. These, there is every reason to believe, represent the lower part of the Câche Creek formation, or some portion of it. How far the series may extend downward, there is no means of ascertaining, but in so far as original similarity of composition may be taken as a guide, there appears to be some reason to believe that part of the local development may represent the rocks of the Boston Bar series.

An area of doubtful age.

To the west of the northern part of the North Thompson included by the map, a considerable tract of country is characterized, in so far as it has been possible to examine it, by dark schistose rocks, in part consisting of finely micaceous argillites and in part of rocks which may originally have been volcanic in origin, some of which show points of resemblance to the Campbell Creek series, subsequently described. No limestones have been found in association with these rocks, and although they have been provisionally included in the Câche Creek formation, this reference is very doubtful. Lithologically they are not unlike some of the Cambrian schists of the lower part of the Fish-trap Rapid section.

Campbell Creek beds.

To the south of the line of the South Thompson, on Campbell Creek, near Douglas Lake and elsewhere in the south-eastern part of the map, the series of rocks designated as the Campbell Creek beds occur.

These consist of dark argillites and fine-grained, bedded, black, slaty amphibolites, with some layers of grauwacke sandstone and some apparently interbedded masses of green uralitic diabase. With the exception of the amphibolites, these rocks closely resemble those found about the North Thompson, but this exception is of so marked a character, while the distance separating the localities is inconsiderable, that it appears necessary to assume it to mark some difference of horizon. The circumstances of their occurrence render it evident that the Campbell Creek beds must belong either to the upper part of the Câche Creek group, as locally developed, or to the lower part of the Nicola formation; for it is clear that these beds hold a position stratigraphically intermediate between the two formations named. It has been decided to be most in accord with our present knowledge of the facts, to include the Campbell Creek beds with the Câche Creek formation, and thus the thickness of this series of beds, (or at least a great part of it, for there may be some overlap of horizons) should be added to that estimated for the Câche Creek formation on the North Thompson in order to represent the total volume of that formation in this eastern part of the map.

Provisionally assigned to Câche Creek.

As elsewhere explained, there is some appearance of a passage without break between the Campbell Creek beds and the lower beds of the Nicola formation, for no really definite line has yet been satisfactorily determined between them. In the case of the unconformable junction of the Câche Creek rocks with those of the Nicola formation on the North Thompson, not far to the east of the margin of the present map,* no rocks resembling the Campbell Creek beds are found, and it is therefore probable, to which ever of these formations the Campbell Creek beds may ultimately be attached, that the stratigraphical break at this place is an important one. Neither are recognizable representatives of the Campbell Creek beds found in the section to the south of Ashcroft (p. 112 B), but the distance which separates this from the typical localities of these beds is so considerable that the argument for unconformity by overlap, which might there be based upon this circumstance, is less cogent.

Campbell Creek beds absent to the west.

On the other hand, no trace of the massive upper or Marble Cañon limestone of the Câche Creek formation as represented in the western part of the map, has been found in the eastern part. To account for this fact it may be conjectured: (1) That if deposited here this limestone has since been removed by denudation; (2) that the upper part of the formation has no representative in this region; (3) or that

Marble Cañon limestones absent to the East.

* See Report of Progress, Geol. Surv. Can., 1877-78, p. 80 B.

it is represented by other rocks, as for instance by the Campbell Creek beds.

The amount of pre-Triassic denudation implied by the first hypothesis is so great that considerable hesitation is felt in adopting it. The abundance of grauwackes and the occurrence of some conglomerates in this eastern part of the Câche Creek formation, appear on the other hand to suggest the occurrence of an approach to littoral conditions, which would favour the acceptance of one or other of the two last named hypotheses.

Probable total thickness of Câche Creek.

The extremely unsatisfactory condition of the rocks of the Câche Creek series for all purposes of measurement, will be understood from the foregoing remarks as well as from the further local details given on later pages. Thus, in endeavouring to give some idea of the total volume of the formation, no even proximately correct data can be quoted. The subjoined summarized section is therefore merely an attempt to indicate the general order of succession, and to some extent the importance of the formation, in the western part of the area of the map. The order is descending :

	Feet.
1. Massive limestones (Marble Cañon limestone) with some minor intercalations of volcanic rocks, argillites and cherty quartzites. At least 1000 feet seen in some single exposures. Total thickness probably at least..........................	3,000
2. Volcanic materials and limestones, with some argillites, cherty quartzites, etc. Minimum thickness about....................................	2,000
3. Cherty quartzites, argillites, volcanic materials and serpentines with some limestone. The thickness of these beds, or of a part of them, was roughly estimated in two places as between 4000 and 5000 feet. Minimum total thickness say...........	4,500
	9,500

The thickness of the lower members of the above section depends upon their development on the east side of the main limestone syncline. It will be remembered that the character of the rocks is somewhat different on the west side, where, in particular, the volcanic materials do not appear to be so important immediately below the Marble Cañon limestones, though perhaps more largely developed at a somewhat lower stage.

To the south of the area of the present map, the thickness of the rocks included in the typical Boston Bar group of the original classification alone, is estimated at between six thousand and seven thousand feet (p. 102 B). The thickness of the beds referred to the Câche Creek formation on the North Thompson, is roughly estimated as about seven thousand five hundred feet (p. 104 B), but, if as above indicated a considerable part—say five thousand feet—of the Campbell Creek beds may be added to this, we obtain a total volume of twelve thousand five hundred feet for the Câche Creek formation in the eastern part of the map.

Thickness of Boston Bar group.

Thus, the entire volume of the rocks of the Câche Creek formation as this is now defined, may be assumed to be about ten thousand feet as a minimum, while I am inclined to believe that it really exceeds fifteen thousand feet.

The existence of rocks referable to the Câche Creek formation in the northern parts of British Columbia has already been alluded to in connection with the general definition of the formation. These rocks have in fact now been found to occur at intervals from the southern boundary of British Columbia north-westwards to the upper waters of the Yukon, characterizing particularly a belt of country which lies to the east of the Coast Ranges, and which corresponds more or less closely with the Interior Plateau of the southern part of the province. Their lithological composition, throughout this length of over 800 miles parallel to the general structure of the Cordillera, is everywhere much the same; massive limestones, cherty quartzites and volcanic products being characteristic.

Câche Creek rocks in Northern British Columbia.

A few characteristic fossils have been obtained in a number of places beyond the limits of the present map. At Stuart Lake (lat. 54° 30′), Dease River (lat. 59° 15′), Frances River (lat. 60° 30′) and on Tagish Lake (lat. 60°), fusuline limestones have been observed.

To the westward of the Coast Ranges (in which it is probable that numerous infolds of Palæozoic rocks will yet be found) a formation known from its fossils to be of Carboniferous age is again well represented. This has, so far, not been very minutely examined or reported on in detail, but it is known to comprise thick beds of limestones, argillites and volcanic materials, the latter being even more characteristic and in greater development than in the region here specially dealt with.*

On the coast.

In the Rocky Mountains proper, or eastern member of the Cordilleran system, the section which must now be regarded as the typical

Carboniferous of the Rocky Mountains.

* See Geol. Mag., dec. II., vol. VIII., pp. 218, 219.

one for these latitudes, is that worked out by Mr. R. G. McConnell.* In this section the Carboniferous period is represented by the Banff limestone series which, including two shaly zones, has a thickness of 5100 feet.† This has yielded a number of fossils, and these show that the series as a whole represents the lower part of the Carboniferous, passing below into Devono-Carboniferous. The later part of the Carboniferous period seems either to be unrepresented, or if represented at all, to find but a partial equivalent in the upper shales. It is thus very probable that before the close of the Carboniferous the present position of the Rocky Mountains formed part of a land area.

Region between Kamloops area and Rocky Mountains.

Thus, the absence of the great Marble Cañon limestones of the Câche Creek formation in the eastern part of the Kamloops sheet, with the appearance already noted of an approach there to littoral conditions, may indicate that this land area of the later Carboniferous extended westward nearly or quite to the eastern edge of what is now the Interior Plateau region. It must, however, be noted, that in some portions of the region between the Kamloops sheet and the Rocky Mountain range, as on Adams Lake and Kootanie Lake, the upper part of the general section includes thick beds of limestone, with greenish and gray schists and black argillites, which are believed to be at least in large part referable to the Carboniferous period.‡ But it is not known to what part of the Carboniferous these belong, and it may very well be that they more nearly represent the horizon of the Banff limestones than that of the Marble Cañon limestones of the Câche Creek formation.

Carboniferous rocks of California, etc.

Carboniferous rocks closely resembling those of the western part of British Columbia will probably eventually be found in the corresponding western portions of the States of Washington, Oregon and California, where limestones of this age have long been known in a number of localities. Mr. J. S. Diller has lately described the occurrence of important volcanic intercalations in the Carboniferous rocks of the Taylorville region of California, thus bringing these into line with the long recognized character of the Carboniferous of British Columbia in this respect. He finds reason to include (though in part doubtfully) a thickness of over fifteen thousand feet of beds in this system at that place.§ Further east, in the Middle Nevada and Wahsatch sections, Clarence King has found the Carboniferous system

* Annual Report, Geol. Surv. Can., vol. II. (N.S.)

† *Op. cit.*, p. 17 D *et seq.*

‡ See p. 29 B, also Annual Report, Geol. Surv Can., vol IV. (N. S.), p. 31 B.

§ Bull. Geol. Soc. Am., vol. III., pp. 372, 374-376.

to consist, in descending order, of the (1) Upper Coal Measure limestone, two thousand feet, (2) Weber quartzites, six thousand feet, and (3) Wahsatch limestones, seven thousand feet, with a total thickness of fifteen thousand feet, the lower portion of the last named formation passing down, however, into the Devonian.* With our present information, it would appear that the Marble Cañon limestones probably represent the upper member of this section, while the lower parts of the Câche Creek formation are equivalent in a general way to its two lower members.

It has already been noted that the lower portions of the Câche Creek formation may be older than the Carboniferous period. The very general blending of the Carboniferous and Devonian systems in the West, shows that no well-marked line need be anticipated at the base of the Carboniferous. The separation of any beds of Devonian age can only be made in the event of the future discovery of characteristic fossils. The same may be said respecting the possible existence of Silurian or Cambro-Silurian beds. Where complete sections have been examined in the western parts of the continent, these usually form a comparatively thin series, intervening between the Cambrian and the Devono-Carboniferous, both of which are very massive formations. In a great mass of strata like that here reported on, there is ample place for such representatives of these rocks, but so far, in the southern part of British Columbia, no fossils of this age have been detected to the west of the Rocky Mountain range. In the far north, however, on the Dease River (Lat. 59° 45′) graptolites of Cambro-Silurian age have been found.†

Possible occurrence of Devonian Silurian, etc.

Triassic.

Stratigraphy and General Relations.—In the Preliminary Report of 1877, the existence of rocks of Triassic age in British Columbia was for the first time made known. The statements then made rested chiefly upon the facts met with in the vicinity of Nicola Lake, and the formation was in consequence named the *Nicola series.* The determination of the age of the rocks depended almost entirely upon the interpretation given to the few fossils obtained from the limestone of McDonald River (Quilchenna Creek) and the relationship established between this limestone and the associated great mass of volcanic rocks. It thus became possible, at that time, to describe the general character

The Nicola formation

* Geology of the Fortieth Parallel, vol. I., p. 248.

† Annual Report, Geol. Surv. Can., vol. III. (N.S.), p. 94 B.

of the series very much in the same terms which might be employed to-day.* Further search has not resulted in obtaining any additional characteristic fossils from this particular limestone, and it may thus be appropriate to quote the original statement made concerning it, as follows :—

Fossils originally found.

"The limestone of McDonald's River, Nicola Lake, was at first supposed to be Carboniferous, but the most diligent search failed to bring to light any characteristic forms of this age, and, on the contrary, resulted in the discovery of the scattered joints of a crinoidal column, closely allied to *Pentacrinites asteriscus*, Meek, of the Jurassic of the Black Hills. It differs from this form, however, in some particulars, but in these it approaches to, and is probably conspecific with, a *Pentacrinites* doubtfully referred to *P. asteriscus* by Hall and Whitfield, and procured from beds of Triassic age in the Pah-Ute Range of Nevada.† Apart from other considerations, this might form a rather uncertain criterion of age, but in the same limestone a *Terebratula* also occurs which can be referred, with very little doubt, to the rather variable species *T. Humboldtensis*, which is also found in association with the crinoid above named, in the same locality in Nevada."‡

The only additional fossil since obtained from this particular locality is one described by Mr. Whiteaves as a species of *Cyrtina* or *Spiriferina* with a very high area, not specifically determinable.

Later discoveries of fossils.

In 1890, another fossiliferous locality was found in the limestones which outcrop near the mouth of the Deadman River, the collections made including two species of Pelecypoda, not determinable, and portions of the guard of a slender Belemite which might be referred to the Triassic period or to one somewhat later. In the same year, in the hills a few miles to the eastward, and at a horizon which appears to be several thousand feet higher than the last, some fossiliferous argillites were discovered. Professor A. Hyatt, who has kindly made a preliminary examination of the fossils obtained from this and a few other localities, designates these as distinctly Triassic, enumerating a *Myacites* like *M. Humboldtensis*, Gabb, a *Daonella* like *D. Lomaneli*, a *Trigonodus*, a *Cardita* and other fragments.

In 1894, a somewhat minute examination was made of the rocks along the east side of the Thompson, south of Ashcroft, in the course

* Report of Progress, Geol. Surv. Can., 1877-78.

† U. S. Geol. Exploration of the Fortieth Parallel, vol. IV., p. 280.

‡ *Op. cit.* p. 171 B. *Pentacrinites* has since been found in three places in California in association with undoubted Triassic fossils. J. P. Smith. Bull. Geol. Soc. Am., vol. V., p. 250.

of which fossils were found at two different horizons, separated by about twelve thousand feet of strata. Of these, the lower yielded a *Daonella* like that last noted, and a *Panopea* like *P. Remondi*, Gabb, while the upper is believed by Professor Hyatt to be of Lower Jurassic age, equivalent to the Hardgrove sandstone, and possibly to the Mormon sandstone of Taylorville, California, from which fossils have lately been obtained. Professor Hyatt enumerates two species of *Rhynchonella*, one like *R. gnathophora*, a *Pecten* like *P. acutiplicatus*, Gabb, an *Entolium* like *E. equabilis*, Hyatt MS. and *Lima parva*, Hyatt, MS.

Fossils of Lower Jurassic age.

In a small detached area of limestone near the 89-mile stable on the Thompson, a few fossils have also been found to which Professor Hyatt attributes an age similar to the last, although the species represented are different.

Strata yielding these inseparable from Triassic.

The above statements summarize all that is really known respecting the age of the Nicola formation from palæontological evidence up to the present time. It will be observed that the original reference of the series as a whole to the Triassic has been gradually strengthened by later discoveries. These, taken in connection with the stratigraphy, in fact seem to show that while the great bulk of the Nicola formation is undoubtedly equivalent to the Triassic, it passes up in a few places into rocks of Lower Jurassic date. The structure and lithology do not appear to afford any means of separating the two faunas or of drawing any line through the great mass of rocks, chiefly of volcanic origin, in which they occur, and it is therefore appropriate and necessary to treat of the Nicola formation as a whole, although recognizing the fact that it probably extends higher than the typical Trias.

Unconformity with Câche Creek.

In several parts of the southern interior region of British Columbia, pretty good evidence exists of an unconformity between the rocks of the Nicola formation and those associated with limestones holding characteristic fossils of Carboniferous age. Such an unconformity is believed to exist in the hills on the north side of the South Thompson, about ten miles above Kamloops and beyond the limit of the present map.* It is also supposed to occur in the rocks near the Thompson River below Kamloops Lake (p. 120 B) and there are indications of its existence in the vicinity of Ashcroft. This unconformity may not, however, be universal, even within the limits of the area here under notice, and the character of the older rocks renders it always very difficult to determine.

* Report of Progress, Geol. Surv. Can., 1877-78, p. 80 B.

Definition of the Nicola formation.

The Nicola group, as originally defined in the report for 1877, was intended to include merely the limestone of McDonald River, with the attached and overlying great series of volcanic materials found in the section on Nicola Lake, as set out on page 77 B of the report cited. Subsequent investigations have, however, shown that greenstone rocks essentially similar to those of the original section, also underlie the McDonald River limestone in the same vicinity, and that they there hold probably at least one other similar thin limestone. These rocks are therefore also now included in the Nicola formation, which here finds its provisional base where they rest upon the dark Campbell Creek beds, already described.

Mapping of the Nicola.

In attempting to define the limits of the Nicola formation on the map, it has had to be separated from the often lithologically similar rocks of the Câche Creek formation on the one hand, and from those of the Cretaceous and later formations on the other. The latter separation is generally not difficult, but when the Nicola rocks are found in association with some of the altered volcanic products of the Lower Miocene, it is often far from easy to decide upon a line, which must proceed upon lithological grounds alone.

The reasons in accordance with which it has been fixed in each part of its extent, together with the doubts attaching to it, are fully explained in the sequel. As already stated, it is quite possible that a practically continuous sedimentation, or effusion of volcanic products, was mantained in some parts at least of the district throughout the later Palæozoic and the earlier stages of the Mesozoic.

Date of granitic rocks.

The more important granitic masses of the region, are evidently later in date than the Nicola rocks, while they are unquestionably earlier than those of the Cretaceous, and their existence and relations to the other rocks frequently affords important information in regard to the upper limit of the Nicola formation. They are probably contemporaneous with some of the larger granite masses found on the coast of British Columbia,* and there can be little doubt that the close of the period of Triassic deposition was brought about by crustal movements either consequent on or productive of the great granitic intrusions of both regions. There is thus undoubtedly a distinct unconformity between the highest members of the Nicola formation and the lowest beds of the Cretaceous, and though this is often more or less masked by subsequent folding and disturbance, it is marked by a distinct change in the character of the materials composing the respective formations,

* Annual Report, Geol. Surv. Can., vol. II. (N.S.), pp. 11 B, 15 B.

as well as by a great limitation of the area of deposition in Cretaceous as compared with that of Triassic times.

Area of Nicola rocks.

The Nicola formation, where it has been recognized, appears to attain its greatest development along the central part of the Interior Plateau of British Columbia. It is most widely spread, and covers a great part of the surface, in a belt of country lying about midway between the inland borders of the Coast Ranges on one hand and the south-western mountains of the Gold Ranges on the other, bounded on both sides by older Palæozoic formations. But it is very frequently concealed by later Tertiary volcanic rocks, and this is the case particularly in the northern part of the Kamloops sheet.

Boundaries.

From what has been said respecting the difficulty of separating the rocks of the Nicola formation from others, it will be understood that while the main outlines shown on the map are believed to be nearly correct, there may be many outliers which have yet escaped definition. Such may very well occur among the flexed and broken rocks of the Câche Creek formation, and it is even probable that some rocks of this series appear in the upper part of the section on Adams Lake and elsewhere in the Gold Ranges, the volcanic materials there being converted into schists, the identity of which can be ascertained only by tracing out their connections with less altered areas.

Composition of the series.

Within the area of the Kamloops sheet, the Nicola formation consists essentially of a great mass of volcanic deposits, with a total thickness of probably ten thousand to fifteen thousand feet. In the lower part of the formation, some thin and probably irregular beds of limestone occur. Here and there throughout the formation, a limited thickness of argillites is found, and, forming the summit, so far as yet ascertained, is another bed of limestone.

The greater part of the volcanic rocks may be described generally under the useful name of "greenstones." Lithologically, these rocks are for the most part found to be altered diabases, with, exceptionally, augite-porphyrites also considerably altered. In regard to their state of aggregation, these volcanic materials represent all the usual products of eruptions, including effusive rocks, sometimes amygdaloidal, and tuffs. There is also, throughout the entire series, more or less evidence of subaqueous deposition and bedding, while no proof has so far been obtained in this district of the existence of sub-aërial accumulations.

General sections.

The following summarized general sections, based on the more detailed descriptions given in the sequel, best represent what is known

of the Nicola formation, in the eastern and western parts of its area respectively. The sections are in descending order.

Thompson River, south of the Ashcroft Cretaceous area.	Feet.	Vicinity of Nicola Lake.	Feet.
Limestone (20′ or more).........	20		
Fine grained felspathic rocks, sometimes well bedded, generally gray..................	1,800	Fine grained felspathic rocks, generally well bedded........	1,200
Tuffs or ash rocks, passing into agglomerates, with some fine grained felsites, gray, purplish and green; a few small limestone beds near the base......	7,840	Diabases, chiefly effusive and sometimes amygdaloidal; some tuffs; two thin beds of limestone near the base......	3,700
Chiefly green diabase agglomerates, often coarse. Several calcareous beds and limestones. Dark felsites at base.	3,930	Chiefly green diabase agglomerates, occasionally amygdaloidal. Thickness at least 2,600 feet, and possibly 6,000 feet (say)........	2,600
Approximate total............	13,590	Approximate total (minimum)..	7,500

In explanation of the above sections, it may be added that although placed in parallel columns, the equivalency of the several groups of beds is intended merely to be suggested in the most general way. If the maximum thickness be assigned to the lower group in the Nicola section, there would be a nearer approximation to correspondence in total thickness, but the rendering of this part of the section is doubtful. Further, it must be noted as possible that the amphibolites and argillites of the Douglas Lake vicinity, with a thickness of about 7000 feet, may eventually have to be added to the Nicola formation in that region. This question has already been alluded to on page 45 B.

Trias of Queen Charlotte and Vancouver islands.

Representatives elsewhere of the Nicola Formation.—In the year following that in which the Triassic age of these rocks was recognized in the inland region of British Columbia and the name Nicola series was proposed for them, Triassic rocks of essentially the same character were discovered in the coast region, in the Queen Charlotte Islands.* At a still later date, the formation last referred to, was found to be continued to the south-eastward, in the line of the same mountain axis, and to form the greater part of the older rocks of the northern portion of Vancouver Island.† Like the Nicola formation, the Vancouver formation, as it was then called, is chiefly composed of

* Report of Progress, Geol. Surv. Can., 1878-79, p. 45 B *et seq.*

† Annual Report, Geol. Surv. Can., vol. II. (N.S.), pp. 7 B-10 B.

old volcanic products, described as follows in the report last cited :—
"These rocks are now represented by hard amygdaloids and agglomerates of general dark greenish colours, though often grayish and sometimes purplish or reddish; by felsites, more or less porphyritic, and by hard regularly stratified ash beds, which, where the alteration has been most pronounced, are locally changed to hornblendic or micaceous schists."* With these volcanic products limestones and argillites holding characteristic Triassic fossils are interbedded.

Equivalency of Nicola and Vancouver.

In the Vancouver formation, or series, the limestones and argillites are somewhat more important than in the Nicola formation, but otherwise the resemblance between the two, both in regard to their original mode of production and their present appearance, practically amounts to identity. Notwithstanding this fact, it is believed to be appropriate to retain distinctive local names for the two great developments of Triassic rocks in British Columbia. In both cases the lower and upper limits of the formation remain more or less indefinite, chiefly because of the absence throughout great masses of the strata of any organic remains, and thus one may extend in its lower or upper beds through a part of the geological time-scale considerably greater than the other. It is morever found to be a general rule in this part of the Cordillera, that exact equivalency of formations is scarcely to be sought for at any considerable distance across the prevalent north-west and south-east trend of the main orographic features, and in this case, the nearest recognized representatives of the two formations are separated by a gap of about 150 miles transverse to this direction.

Triassic of the north.

It is unnecessary in the present connection, and in the as yet incomplete state of our knowledge of the Triassic rocks of the west, to enter into any extended comparison of the Nicola formation with other rocks believed to be of the same age. It may suffice to point out that characteristic Triassic fossils, like those of the Nicola and Vancouver formations, have now been found in a number of places very far to the north and north-west of these typical localities, as on the Stikine, Liard and Peace rivers and even in the Alaskan peninsula;† and that it is evident that in this northern region the Triassic sea extended eastward completely across the Cordilleran belt. To what extent volcanic materials are mingled with those of ordinary sedimentary origin in these northern localities, remains in most

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* *Ibid*, p. 8 B.

†See Annual Report, Geol. Surv. Can. vol. III. (N.S.), page 54 B; *Ibid.*, vol. IV., page 19 D; Report of Progress, Geol. Surv. Can.,, 1875-76, p. 97. Bull. Geol. Soc. Am., vol. V., p. 122.

Rocky Mountain red beds.

cases still to be determined. It may further be noticed, that no rocks like those of the Nicola formation are found in that part of the Rocky Mountains proper which is situated in latitudes similar to those of the region here particularly described, but on the contrary, that about as far north as latitude 49° 30′, certain red beds, the deposits of an inland sea, are there believed to represent the Triassic period. Between the northern part of this inland sea and the extension of the ocean in which the Nicola and Vancouver formations were laid down, land, occupying approximately the position of the Selkirk Range, appears to have formed a barrier.*

Comparison with southern Triassic.

To the southward, in the corresponding portion of the Cordilleran belt of the western part of the United States, the nearest available term of comparison for the rocks here described is found in the Taylorville region of California, some 700 miles distant. It is not intended to suggest that the intervening portion of the Cordillera differs in its structure, but it has not yet been carefully examined or studied, and in regard to all formations older than the Cretaceous, it remains practically unknown. Such cursory observations as I have been able to make in travelling through this intermediate region, comprised in the states of Oregon and Washington, lead me to believe that rocks representative both of the Nicola and the Câche Creek formations of British Columbia will ultimately be found to extend without any important break to California.

The Taylorville sections.

In the Taylorville region,† near the fortieth parallel, in northern California, the rocks have been examined in detail, stratigraphically and palæontologically, by Mr. J. S. Diller, Professor A. Hyatt and others. The results arrived at by the two gentlemen named are given in a summarized form in papers contained in the Bulletin of the Geological Society of America.‡ It is there shown that the Triassic rocks are unconformable on those of the Carboniferous, that these rocks as locally developed are all referable to the Upper Trias, later than those of the Aspen Mountains, Idaho, or of the Star Peak Range, Nevada, while they are supposed to be limited above by a second unconformity which separates them from beds containing Jurassic fossils.§ No unconformity corresponding to the last has been recognized in

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* For a further discussion of this point see Trans. Royal Soc. Canada, vol. I., sect. IV., p. 143 *et seq.*

† An area about 12 miles in length by 6 miles in width.

‡ Vol. III., 1892, pp. 369-412.

§ *Ibid.*, pp. 378-379. See also vol. V., p. 399. The evidence of the Jura-Trias unconformity as given by Mr. Diller, does not appear to be entirely satisfactory for a region so much disturbed as that of Taylorville.

British Columbia where, on the contrary, the fossils referred by Professor Hyatt to the Lower Jurassic, occur in beds which appear to be conformable with those of the Triassic and which are included with them in the Nicola formation of this report. A great orogenic movement, however, took place previous to the deposition of the lowest Cretaceous beds, which is probably equivalent to the important unconformity in California elsewhere referred to by Mr. Diller.* Nothing beyond the few fossils above referred to, of supposed Lower Jurassic age, has yet been found in British Columbia to bridge the gap between the Triassic and Cretaceous, for the beds on the Iltasyouco River (Lat. 50°, Long. 126°), at one time supposed to be Jurassic, have been united by Mr. Whiteaves with the Cretaceous.†

Volcanic materials.

The most interesting circumstance met with in the comparison of the sections examined by Mr. Diller with those of the Nicola formation, is the considerable proportion in which materials of volcanic origin enter into the composition of both, and the evidence thus afforded of the widespread character of volcanic action at this time.‡

It is, however, probable that the lower rocks of the Nicola formation are considerably older than any of those recognized in the Triassic of the Taylorville district, and that the formation as a whole may correspond more closely with the period represented by the Triassic rocks of the Fortieth parallel region to the east of the Sierra Nevada and between that range and the Wahsatch Mountains, as described by Clarence King.

Nevada section.

The rocks of this system are there divided into upper and lower series, designated as the Star Peak and Koipato groups, respectively, with a total thickness of some 16,000 feet. These rocks generally rest upon an Archæan foundation, but pass conformably upward into the Jurassic. They are to a great extent composed of materials of ordinary sedimentary origin, but the important development in them of materials described as "porphyroids" and in some cases as "chloritic schists," induced me long ago, in the light of the composition of the Nicola formation, to venture the suggestion that such rocks really represent contemporaneous volcanic materials, although in the Geology of the Fortieth Parallel their character is accounted for as the result of some peculiar metamorphism. This suggestion has not yet,

* *Ibid.*, vol. IV., p. 221.

† Report of Progress, Geol. Surv. Can., 1876-77, p. 158. Geological Magazine, decade II., vol. VIII. (1881), p. 218. Whiteaves, Mesozoic Fossils, vol. I., part III., p. 258.

‡ Bull. Geol. Soc. Am., vol. III., p. 376, etc. See also J. E. Mills on an adjacent part of California, p. 426. The rocks described by him are shown by Mr. J. P. Smith to be Triassic. *Ibid.*, vol. V., p. 250.

so far as I am aware, been borne out by any later investigation of the rocks, but it appears to me to be, in connection with the facts now established in the Taylorville region, more than ever probable.*

Conditions of Metamorphism affecting the Older Volcanic Rocks.

Metamorphism of volcanic rocks.

In order to understand the different forms in which the volcanic rocks of the Nicola series now appear, it is necessary not only to refer them to the original materials which they may be supposed to represent, but also to examine into the causes of alteration which have since operated upon them. In such an examination, the metamorphism of the ordinary sedimentary materials and of the limestones, which constitute a relatively small part of the great Triassic series as here developed, may be passed over, as being well understood and presenting no features not easily recognized. It is in respect to the mass of rocks of volcanic origin, of which by far the greater part of the formation is built up, that questions surrounded with greater difficulty and doubt arise.

Amphibolites of Campbell Creek.

The fine-grained amphibolites, which in association with hard slaty or schistose argillites constitute an important feature in the Campbell Creek section and in the vicinity of the Douglas Lake granite mass, (pp. 122 B, 136 B) although assigned provisionally to the Câche Creek formation, may be mentioned in connection with the remarks here made on the Nicola volcanic rocks. This is appropriate by reason of their association in the field, and also because they seem to illustrate what may be merely another form of metamorphism to which such volcanic materials are subject. Miscroscopic examinations of some of these rocks made by Mr. Ferrier, lead him to believe that they have resulted from the dynamic metamorphism of basic igneous materials, which may have resembled the diabases common in the Câche Creek formation, or those which constitute the greater part of the Nicola formation. There are, however, other varieties, difficult of study under the microscope, but which in the field, evidently grade into hard black argillites and into grauwacke sandstones, and in which no evidence of a foliated structure as distinct from the bedding planes are found. It does not, therefore, appear probable that these dark-coloured, fine-grained rocks have revolted merely from the metamorphism of the ordinary diabase porphyric. When evidently subjected to dynamic metamorphism, these ordinary diabases are observed to produce green and gray, lustrous, chloritic and sericitic schists. Where

Their mode of origin.

*See Trans. Royal Soc. Can., vol. I. (1883), p. 145. Geology of the Fortieth Parallel, vol. I., pp. 268, 271-272, 275.

affected merely by the temperature consequent on contact with granitic masses, they are found to pass into gray rocks of gneissic appearance, but free from quartz.

It is in fact supposed, that these amphibolite schists may represent highly altered basic tuffs, which have been deposited in water with frequent admixture of ordinary clayey material, and that their appearance of bedding really depends upon their original arrangement as sediments rather than upon any subsequent foliation. In any case, they appear to constitute, in the Stump Lake and Upper Nicola region, a set of beds with recognizable and somewhat peculiar characters which are of classificatory importance from a stratigraphical standpoint.

It may, however, still be argued that these amphibolites have been produced from the ordinary diabases of the region by a combination of temperature (or contact) and pressure effects, differing from that of either of these factors acting separately. I am not prepared to deny that this may be the case, although some of the circumstances cited above are opposed to such a belief.

Metamorphism near granite contacts.

Reverting to the other forms of alteration which are met with in the region, a few words may now be said respecting the kind of change which is clearly referable to the proximity of extensive granitic masses and may be described as a contact phenomenon. This is not equally apparent in the case of all contacts of these old volcanic rocks with the granites, a circumstance for which the reason cannot be given with certainty, but which very possibly depends largely upon the angle which the intrusive mass makes with the present surface. For, upon the assumption that the effect in the matter of alteration is equal in the case of each contact, it is obvious that this effect would be apparent for a relatively small distance when the plane of contact is vertical to the actual surface, while it might extend very much further when this plane cuts the surface obliquely. But in addition to this, it must be noted that a much greater degree of heat, of hydrothermal action and of pressure may have attended some of the contacts than that found in the case of others.

Changes observed near contact.

In the southern and stratigraphically higher part of the section which has been referred to as the Campbell Creek section, what is believed to be the normal change attending a contact of the diabases of the Nicola formation with granite is very well exemplified. The nature of this alteration is explained in some detail elsewhere (p. 123 B). It may suffice here to say that the green colour due to the general

alteration originally suffered by the diabases, and resulting from a change of a part of the augitic constituents into chloritic minerals which have become diffused through the mass of rock, has in this place and in others similarly situated, been eliminated. The ferruginous and basic constituents of the magma have rearranged themselves into black or dark-coloured new crystals of hornblende, while the felspathic constituents have recrystallized in colourless forms. The general tint of the rock thus changes from green to gray, and when nearly in contact with the granite it assumes a gneissic structure, though free or almost free from quartz. Mica is also very frequently developed along the planes of bedding or foliation, but this appears to result chiefly from the effect of pressure superinduced on that of the metamorphism due to mere increase of temperature.

Various granite contacts.

Along the zone of contact of the diabase series with the granites on the line of Moore Creek (p. 129 B) pressure appears to have played a considerable part in the aggregate change of the rocks. The neighbouring parts of the granite are often foliated, and gray micaceous-looking schists are frequent, though many of them when carefully examined are found to have the characters of amphibolites or epidiorites in so far as the bulk of their constituents is concerned. The same phenomena are repeated near the head of Clapperton Creek (p. 143 B), in some places on Guichon Creek (p. 144 B) and to the west of Jacko Lake (p. 138 B).

Dynamic metamorphism.

When, at any considerable distance from the granitic masses, the altered diabases have been subjected to great pressure alone, they tend to pass, as already noted, into the green and gray chloritic or sericitic schists, which are often lustrous and sometimes contorted and wavy in their planes of foliation. All intermediate stages between such rocks and massive and distinctly porphyritic diabases may be found in different parts of this field, and along the southern side of Nicola Lake (where this particular kind of alteration was chiefly noted as affecting the Triassic rocks) it is observed to be best marked in the vicinity of the compressed anticlinal axes. It is there also observed that the rocks so affected are usually highly calcareous, and it is possible that materials originally containing a considerable proportion of lime have passed most easily into such glossy schists.

It may here be remarked that, in the case of such schists within the area of the Kamloops sheet, no criteria have been found which, apart from stratigraphical evidence, suffice to determine their age. Under like conditions, rocks of originally similar character whether Triassic, Carboniferous or Cambrian in age, have been changed into

green and gray schists in themselves indistinguishable. Neither is it possible in hand specimens, to make any distinction between the greenstones or altered diabases of these several and widely separated geological horizons.

Original character of Nicola rocks.

Respecting the original character of the materials of the Nicola formation, now found in the various stages and kinds of alteration above referred to, it may confidently be stated that they have appeared as volcanic rocks not necessarily different from those which now reach the surface in regions of vulcanism. The great bodies of volcanic materials which at recurrent intervals appear to characterize so many different stages in the entire geological history of this part of the Cordillera, in themselves afford a practical clue to every step in the alteration of such deposits. The greenstones, or green altered uralitic diabases, now so abundant in strata of Triassic age and older, have undoubtedly at one time reached the surface as dolerites or as basalts, which in some cases have been effusive, in others of the character of volcanic breccias, or the finer forms of volcanic ashes or tuffs. Such deposits, whether thrown down sub-aërially and afterwards covered by later strata, or scattered and spread abroad in the waters of the sea of the period, are essentially the same. Under the last-named conditions, they are often well stratified, but unless subjected for prolonged periods to the leaching action of water, or intermixed with considerable proportions of calcareous or ordinary earthy deposits (both conditions which can only have prevailed when the rate of supply of the volcanic material was slow) they are the same in composition and remain subject to a similar series of changes.

Analogy with Tertiary volcanic rocks.

In the Tertiary volcanic rocks which cover so large a part of the same area, we find without difficulty the little changed or practically unaltered representatives of all the older volcanic rocks. The massive basalts, dolerites, melaphyries and augite-porphyrites, with agglomerates composed of these rocks, afford the materials which, by a breaking down of their original constituents and some concurrent recrystallization of them, lead to the production of diabases. By a further change, affecting principally the augite of the diabase and resulting in its conversion into hornblende, wholly or in part, the characteristic "greenstone" or altered diabase of the region may be formed, of which the still further changes have already been traced. In a similar manner, the bedded tuffaceous rocks of the Tertiary evidently represent the clastic materials of many of the older rocks. The acidic volcanic rocks need not be considered here in detail, for though rocks of this character are present in the Tertiary accumulations, they have not so

far been recognized as playing any important part among the older rocks of this particular region.

Cretaceous.

Eastern limit of Cretaceous.

Strata referable to the Cretaceous period, occur in the western half of the Kamloops sheet alone, and there only as insets among the older rocks due to folding, or folding and faulting combined. These rocks have not been recognized to the east of the Ashcroft Cretaceous area, and a more general survey of the conditions in British Columbia renders it probable that the Cretaceous sea at no time extended much further east in this latitude. The deposits consist largely of coarse clastic materials, including massive conglomerates, which in all probability indicate a sinking shore-line. But it is further evident that we can now possess but residual fragments of a formation which must at one time have been much more extensive, for the conditions imply that at the time of the deposition of these beds the Coast Ranges were either non-existent, or that they were broken and discontinuous, so that the Pacific Ocean of the period obtained free access nearly to the centre of the region which now forms the Interior Plateau of British Columbia.

Areas in map-sheet.

The residual Cretaceous areas of the Kamloops sheet, which have escaped the great post-Cretaceous denudation, may be designated as the Fraser River area, the Ashcroft area and the Botanie Creek area respectively ; the last-mentioned being quite inconsiderable in dimensions.

Composition of the rocks.

The excessively crushed and disturbed condition of all these Cretaceous rocks, has so far rendered it impossible to obtain any complete general section of them ; but it would appear that in the Fraser River area, hard black argillites and black fine-grained sandstones or quartzites form the lower part of the series, while gray and green-gray sandstones, with massive conglomerates, prevail in its upper part. In the Ashcroft area, on the other hand, the lower part of the formation seems to consist chiefly of green or green-gray sandstones or quartzites, while dark, shaly, and fine-grained sandstones are more abundant in its upper parts, conglomerates being less important at all stages. In the Ashcroft area there are, however, some coarse subangular grits and conglomerates towards or at the base which appear, to represent true "basal conglomerates." These, in one place (about two miles south-east of Black Cañon), are represented by a bouldery conglomerate, passing below in a few feet into an angular breccia, which rests unconformably upon the Nicola rocks. The conglomerate

and breccia are here almost entirely composed of granitic material of proximately local origin, with a calcareous and arkose paste.

The Ashcroft area lies some twenty miles to the east of the Fraser River area, and it is quite possible that its lower, coarse, clastic beds, may represent the littoral equivalents of a portion of the lower beds of the Fraser River, while the conditions for the deposition of finer beds may have extended to both areas at a later stage with an increasing depth of submergence. In this case, it may be conjectured that the higher portions of the series as represented along the Fraser, are now not found in the portion of the formation preserved in the Ashcroft basin. It must, however, be explained, that in both areas no definite line of division exists between the different classes of rocks, sandstones, conglomerates and argillites occurring more or less indifferently at all stages.

Thickness.

The thickness of the entire series in the Fraser River area, is estimated to be about 7000 feet, while in the Ashcroft area about 5000 feet of beds appear to be represented, and it is not improbable that if a complete section could be reconstructed, the Cretaceous rocks would be found to possess in the aggregate a volume approaching 10,000 feet.

Character of sandstones and conglomerates.

The greenish and green-gray hard sandstones or quartzites which form so large a part of this formation, are so peculiar in character as to deserve a word of special mention. On microscopic examination some of these rocks appear to be chiefly composed of granitic débris, and may therefore be termed arkose rocks or sandstones, while others have all the characters of diabase tuffs.* But the occurrence of true tuffs implies the existence of volcanic eruptions contemporaneous with their deposit, of which there is no definite proof within the limits of the region here under consideration. The underlying and adjacent Triassic and Palæozoic rocks, however, abound in diabases and such-like materials of volcanic origin, and it is probable that the rocks here spoken of are in many cases reconstructed or secondary tuffs or grauwackes composed of such materials, when these instead of the granitic rocks have constituted the source of supply of débris going toward the formation of the Cretaceous sediments. The composition of the conglomerates, with that of beds intermediate in coarseness of constituents between these and the hard greenish sandstones, go far to support this view. It must, however, be added that, in other parts of the Cordillera, the products of contemporaneous volcanic eruptions have

*See Appendix I., Nos. 38, 39, 40.

entered largely into the composition of the Cretaceous beds and particularly into those of the Earlier Cretaceous.*

Geological position.

Respecting the precise geological age of these rocks, it may here be sufficient to state that they are, for the most part, the local representatives of a great Earlier Cretaceous series which is very widely spread in British Columbia, and of which the fossils from a number of localities have now been studied in detail by Mr. J. F. Whiteaves. To this, the name Queen Charlotte Islands formation has been applied as a general one, as from these islands the greatest body of palæontological evidence, with the best general section of the rocks, has been derived.

For further details on the equivalency of this with other recognized Cretaceous areas, earlier publications by the writer and Mr. Whiteaves may be consulted.†

Fossils obtained.

Within the area of the Kamloops sheet, the whole number of Cretaceous fossils so far found is very small. In addition to the few plants elsewhere mentioned, only two species of molluscs have actually been determined. These are *Aucella Mosquensis* var. *concentrica* and *Pecten (Syncyclonema) Meekiana*. No fossils have yet been obtained from the Ashcroft area.

Beyond the edge of the present map, however, the Cretaceous rocks run along the Fraser valley for many miles to the southward, the trough terminating in a mountainous country to the east of Boston Bar and North Bend.‡ This southern extension of these rocks was examined by Dr. Selwyn in 1871, and the rocks were then provisionally referred to by him as the "Jackass Mountain Group," though their age was unknown.§ Subsequently (in 1875) these rocks were, on lithological grounds, correlated by the writer with those of Tatlayoco Lake (of which the age had been fixed by fossils)|| ; but in 1877 they were found to yield some fossils in Dr. Selwyn's original locality, and these bore out the reference just alluded to. The fossils obtained at that time, which may be taken as equally characteristic of the rocks of the Fraser River area within the present sheet, are *Belemnites impressus*, Gabb, *Pecten (Syncyclonema) Meekiana*, Wh., *Ancyloceras percostatum*, Gabb,

* Reports of Progress, Geol. Surv. Can., 1876-77, p. 58 ; 1878-79, p. 69 B ; Annual Report, Geol. Surv. Can. vol. I. (N.S.), p. 164 B.

† See especially Am. Journ. Sci., vol. XXXVIII., p. 120 ; Trans. Royal Soc. Can., 1893, sect. IV., p. 3.

‡ Report of Progress, Geol. Surv. Can., 1877-78, p. 107 B.

§ Report of Progress, Geol. Surv. Can., 1871-72, p. 60.

|| Report of Progress, 1875-76, p. 253.

Crioceras latus, Gabb, *Pholadomya Vancouverensis*, Wh., an *Arca* like *A. Carteroni*, D'Orb., and a *Cucullæa*.*

The small collection of fossil plants which is reported on by Sir J. Wm. Dawson on a following page (p. 148 B), goes to show that beds as late as the Dakota period must occur in the Fraser River area, and this is quite in accord with the general views previously enunciated of the limits of the Earlier Cretaceous series of British Columbia.†

Equivalency

We have here in fact beds equivalent to those of the Queen Charlotte Islands formation (including the three lower subdivisions of the general section in these islands‡) together with higher beds, which like the conglomerates of the Queen Charlotte Islands (subdivision B) and other conglomerates found on the Lewes River and in the Kootanie district, represent the Dakota period with possibly some part of the Benton period, of the province of the Great Plains. Further, these Earlier Cretaceous rocks correspond in a general way to the group long known in California as the Shasta group. The molluscs above enumerated appear to be essentially those of the Knoxville or lower division of that group.

Upper limit uncertain.

It has been found impossible to determine any of the fossils in a small collection obtained on Stein Creek, but these appear to be fresh-water forms. Whether they represent a stage during which the sea was actually excluded from a part of the region, is not known, nor can the stratigraphical relation of the particular beds in which they occur to the others be stated. It is of course quite possible that these beds, or others which may yet be discovered, may be found to be related to parts of the Cretaceous even higher than the Dakota horizon. The late determination, by Messrs. Diller and Stanton in California,§ of the fact that the Shasta and Chico form parts of a practically unbroken series there, tends to indicate that similar conditions may prevail here also, but no fossils characteristic of the Chico period have so far been found on the mainland of British Columbia.

Relations of Cretaceous and Coldwater conglomerates

In concluding these general remarks on the Cretaceous, something should be said on the possible relation to it of the conglomerates elsewhere referred to the Coldwater group and described as probably Oligocene (pp. 68 B, 76 B). The question has several times occurred, whether these conglomerates may not actually represent local developments of

* Report of Progress, Geol. Surv. Can., 1877-78 pp. 108 B, 109 B.

† Am. Journ. Sci., vol. XXXVIII., p. 125.

‡ Trans. Royal Soc. Can., 1893, sect. IV., p. 15.

§ Bull. Geol. Soc. Am., vol. V., p. 435.

parts of the Cretaceous series elsewhere represented in the region, or an upper member of that series. This suggestion cannot be quite definitely negatived, but I believe the evidence to be almost conclusive against it. In its favour, the very high angles at which the conglomerates in question are often found, and the occasional occurrence in them—particularly as basal beds—of conglomerates lithologically closely resembling those of the Cretaceous, may be cited.

On the other hand, we find them in aspect and composition generally, to differ much from the Cretaceous conglomerates, while the associated sandstones are also very different in the two cases. Still more conclusive, however, is their apparently definite association with undoubted Tertiary lignite—and coal-bearing rocks at Hat Creek and on the Nicola. The fact that these conglomerates occur on Hat Creek in a position geographically intermediate between the Ashcroft and Fraser River Cretaceous areas, while quite unlike the rocks of either, and unaffected by the severe compression which has affected both of these areas, is also significant. It remains, however, still possible, that isolated areas of conglomerates due to the Cretaceous period may have been confounded with the Coldwater conglomerates proper in some cases.

Economic features.

The Cretaceous formation as represented in this region is not entirely without economic interest. The evidence of the fossils shows that it represents a stage of the Cretaceous at which in the Queen Charlotte Islands on one hand and in the Kootanie region of the Rocky Mountains on the other, important coal-beds were in process of deposition. No coals have yet been found in these particular rocks, but the occurrence of carbonaceous shales and of plant remains, serve to show that a slight change in the conditions in some part of the extent of the formation might have led to the production of coal, which may in that case yet be discovered.

Again, the massive conglomerates of the Cretaceous have possibly had something to do with the supply of gold in adjacent parts of the Fraser Valley, for these conglomerates, representing as they do an extensive Cretaceous erosion, may well have become in certain layers charged with gold derived from the older rocks, which may subsequently have found its way, in the course of later erosions, into the bed of the present river. This subject is, however, returned to in the sequel.

Tertiary.

Earlier observations.

In my preliminary report on the southern portion of the interior of British Columbia,* the Tertiary strata were treated of as a whole and

*Report of Progress, Geol. Surv. Can., 1877-78.

no attempt was made to establish subdivisions among these strata. The following statement on this subject was, however, made:—"It is by no means improbable, that the Tertiary rocks of this part of British Columbia may eventually admit of separation into several distinct series representing different stages in the Cainozoic period, but palæontological evidence of this is yet wanting." (p. 112 B).

Several members in the Tertiary.

The much more detailed examination of that part of the same region now included in the Kamloops sheet, still fails to afford the necessary palæontological data for any complete subdivision of the Tertiary rocks. So great a part of these rocks is moreover of volcanic origin, that it is perhaps too much to expect the discovery of sufficient evidence of this kind from the relatively insignificant sedimentary beds. It has, however, become very clearly apparent that the rocks here collectively referred to as Tertiary, represent a very long period of time, with several changes of condition, and that there are also probably one or more gaps, unrepresented so far as known by deposits of any kind. These general facts are established chiefly by the stratigraphical and other physical characteristics and relations of the rocks, but they are borne out also in a measure by the slight evidence to be obtained from fossils. These consist almost exclusively of plant and insect remains, obtained from several localities, of which one of the most striking peculiarities is the diversity of each collection from the others. On this particular subject, a few more detailed notes are given in the sequel.

Method of treatment in Report.

The impossibility of defining separate formations of the Tertiary, even for the area of the Kamloops sheet, thus still renders it appropriate to speak of these rocks in the aggregate, as they are met with in each particular natural district. An attempt to follow a systematic order of treatment, would involve an undue reliance on hypotheses which subsequent investigation may prove to be more or less unsound. A general sketch of the composition and relations of the Tertiary strata as a whole, will therefore first be given, in this part of the Report, together with such facts or theories as have been reached or are tentatively held on the equivalency and correlation of horizons. Each naturally defined area will then, in a subsequent part of the Report, be separately described, taking first and in greatest detail those in which the more complete and instructive sections have been found. Briefer mention will in the last place be made of the Tertiary rocks of the other parts of the region. This method of treatment does not admit of a strictly geographical order of description, but if followed with the aid of the map, will, it is believed, give the best picture of the whole.

Degree of accuracy in delineation.

To avoid possible misconception, it must further be stated that the Tertiary rocks were originally examined in the field as an aggregate, and that it became apparent only in the course of this work that they might be usefully subdivided into the several groups now adopted. Thus, while the outlines of the Tertiary as a whole are believed to be shown on the map with such accuracy as its scale and the nature of the surveys admit, the separation of the volcanic materials of the formation into upper and lower parts is of a much inferior order of precision. It indeed became a question in the compilation of the map, whether any attempt to outline the several areas of these two members of the Tertiary should be made, but it was eventually decided that it would be best to indicate these as nearly as possible, with the proviso that such indication must be regarded as a first rough sketch only of the facts.

Coldwater group.

Before the beginning of the period of Tertiary vulcanism in this region, certain beds had been deposited which consist entirely of ordinary clastic materials. These beds were laid down in lakes or river-estuaries, in hollows then existing in the old denuded surface of the Palæozoic and Triassic rocks. They consist chiefly of conglomerates, sandstones and shales, with which coals and lignites are in some places associated. These particular beds have not been found in actual unconformity with the upturned Cretaceous rocks of the Thompson or Fraser, but as they do not appear to have participated in the great crumpling of the Cretaceous, which probably took place at or about the close of the Laramie period, they are regarded as post-Cretaceous and probably as post-Laramie.* They may therefore be described as intervening between the close of the Cretaceous and the inception of the great volcanic period in this region.

Its character.

The nature of the deposits, and particularly the abundance of well-worn conglomeritic material in them, seems to show that they may very well represent the work of some river systems of the great early Tertiary time of denudation, during which the Interior Plateau was being worn down to an approximately level surface. Particularly on the interruption or close of this period, might such deposits be formed.† But as the time involved was undoubtedly very long, the isolated deposits now found in various parts of the field might very well be referable to horizons differing widely, although all included in the early part of the Tertiary.

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* See however p. 65 B.

† In my paper on the Physiographical Geology of the Rocky Mountain Region, already referred to, these deposits are not separated from those classed as Miocene. The facts here stated show that they probably belong to an earlier period, most likely to some part of that described on p. 11 of the paper above referred to.

It is found, however, that there exists, in several separate localities, so complete a lithological resemblance and similarity in the order of superposition of these deposits, that there can be little, if any doubt that the beds of these localities are contemporaneous and due to the same sequence of events in the Tertiary history. The deposits thus evidently related are those of the following places:—Hat Creek valley, Copper Creek, vicinity of the confluence of the Coldwater and Nicola, and, (to the south of the Kamloops sheet) near Lac à la Fourche. In each of these places the lowest beds are found to consist of conglomerates almost entirely composed of materials of proximately local origin, followed by conglomerates largely composed of well-rounded cherty pebbles, with which some sandstones are associated. Above these, in the Coldwater-Nicola vicinity and on Hat Creek are sandstones and shales with coals and lignites.

Identity of several developments.

It is proposed to designate these evidently synchronous deposits by the name of the *Coldwater group*, and there can be little doubt that the conglomerates found on the plateau to the west and south of Savona, as well as these forming small outliers on the Garde Lafferty, represent further remnants of the basal conglomerates of the same series. In the case of the sedimentary deposits of the North Thompson, situated near the north edge of the map, no distinct lithological identity can be appealed to, but there is at least nothing to show that they differ in age from those of the Coldwater group.

The Coldwater group as a whole, evidently represents the remnants of a once more extensive formation, most of which has been removed by denudation, and of which what still exists is often covered by the later volcanic materials. It may in part be regarded as filling hollows in the pre-existing surface, but this surface has since been considerably modified in its relief by later flexures and by some faulting, and it is thus generally in synclinal folds, or where let down by faults, that the Coldwater beds are actually found. It is, therefore, impossible now to determine whether the remaining beds of the series represent portions of a deposit once largely spread over the area of the Kamloops sheet, or, if more restricted, what areas such deposits may originally have covered.

Original extent uncertain.

That these deposits antedate the period at which volcanic activity on a great scale began, is rendered evident by two circumstances. They include in their material no characteristic volcanic Tertiary rocks while they appear without doubt to be affected by more pronounced folding than that affecting the volcanic rocks.

Older than volcanic Tertiary

In some places these beds are now nearly or quite vertical. This is particularly the case near Clapperton and Copper creeks; but in other

Attitude of the strata.

localities, as for instance on the plateau to the west and south of Savona, the basal conglomerates are found to be still nearly horizontal, or inclined at comparatively low angles like those normal in the case of the later volcanic rocks of the Tertiary. In the place last mentioned, not only are the basal conglomerates nearly flat, but they differ but a few hundred feet in elevation from their similarly undisturbed representatives in outliers on the Garde Lafferty—twenty miles distant. Thus it would appear, that after the Coldwater beds had been laid down, a period of orogenic movement occurred, by which these beds were affected particularly along certain lines, running in north-north-west by south-south-east bearings, while large intervening blocks of country preserved their rigidity; that a period of denudation followed, during which a great part of the Coldwater beds was removed, and that the denudation had been long in progress before the first beds of the succeeding volcanic series were formed.

Relation to Nicola rocks.

In connection with the relations of the Coldwater beds, it may further be noted that, though unconformable on the rocks of the Nicola formation, they are found near Clapperton Creek, and south of Lac à la Fourche to rest on certain purplish porphyrite rocks which are believed to occupy a position not far from the summit of that formation, a fact showing that the beds of the Nicola formation may not in some places have suffered very extreme disturbance before the time at which the deposition of the Coldwater beds began.

Character of conglomerates.

It has already been noticed that the basal beds of the Coldwater group, consisting chiefly of conglomerates and breccia-conglomerates, but with some grauwacke and arkose sandstones, have derived their materials largely from the immediately underlying surface. The conditions are such as to imply a somewhat rapid working over of that surface by the gaining waters of the lake or lakes in which the Coldwater beds were formed. Above these, and by a gradual passage, the conglomerates become charged with well-rounded pebbles, preponderately of cherty materials, and these conglomerates are perhaps the most characteristic lithological feature of the series, having a great thickness, particularly on the lower part of Hat Creek and on Copper Creek. The cherty pebbles have evidently been derived from the Câche Creek beds, referred to the Carboniferous period, which are found to have their greatest development in a zone of country running southward from Clinton, in the vicinity of the Bonaparte and Thompson valleys, to latitude 50° 30′. Still further to the south, this zone appears now to be entirely covered by the later volcanic rocks of the Tertiary, but its occurrence in that part of the region may

Origin of cherty pebbles.

be argued from the composition of the conglomerates near Clapperton Creek and Lac à la Fourche. It is further apparent, that the rocks of this zone must, at the time of the formation of these conglomerates, have occupied a position more prominent than they now do with respect to the general relief of the surface; while the appearance of so great a proportion of the cherty material in the conglomerates, where these are now found at some distance from the beds yielding this material, indicates the existence of rapid streams, actively engaged in the erosion of the strata of the cherty zone and capable of carrying their débris away with ease. The volcanic rocks of the Nicola formation, of which the main development lies to the eastward of the line occupied by these conglomerates, although they had contributed so largely to the Cretaceous rocks, were not at this time supplying much material to the conglomerates, nor are the limestones of the region west of the Thompson often represented.

Orogenic change closing Coldwater epoch.

All this argues considerable orographic change both before and since the time of origin of the conglomerates, while the later Tertiary rocks are evidently in their physical relations much more nearly in accord with the conditions of surface still obtaining in the region. In other words, there is every reason to believe that an unconformity due to orogenic movement along certain lines, followed by a period of erosion, separates the Coldwater beds from all the later representatives of the Tertiary. Local deposits due to this period of crustal movement may exist in some parts of the region, but if so they have not yet been clearly recognized as such, although tuffaceous sandstones are not infrequent at the apparent base of the overlying volcanic series.

Early Miocene volcanoes

After the events above noted, the great period of Tertiary vulcanism began. The principal volcanic centres within the area of the Kamloops sheet, were evidently situated along the line formed by the Clear Mountains, Mount Murray and Arthur's Seat. Here the volcanic action was probably initiated. The high mountains above designated represent the greatest mass of volcanic materials in the district, and many circumstances discovered during the investigation of the geology of the region, go to show that the main vents (during at least the whole of the earlier stages of vulcanism) were situated along this line, parallel in direction to that of the Coast Ranges, but separated from these ranges and lying a little to the east of them. Further to the south-eastward, although no prominent mountains of the same kind are found in the vicinity of the Nicola, the great thickness of the lower volcanic members of the Tertiary there, indicates the continuation of the same line of eruption and probably that of local subordinate vents. There

were also no doubt other lesser foci of eruption at the same time in different parts of the Interior Plateau region.

Products of their eruption.

The rocks of which the Clear Mountains are principally composed, may be described as consisting of hard, gray, greenish and purplish augite-porphyrites with occasional examples of diabase-porphyrite. These comprise both effusive and fragmental materials. Other rocks met with in these mountains or in their vicinity are noted in connection with the more detailed descriptions given in a later chapter.

In the vicinity of the Nicola Valley, the products of the earlier eruptions are represented by very similar porphyrites and porphyrite-agglomerates, passing into tuffaceous agglomerates and including many other varieties of volcanic materials in lesser quantity; the aggregate thickness being about 5300 feet.

Persistence of volcanic action.

One of the detached minor vents which appears to have been active to some extent during this earlier period of vulcanism, is that of Kamloops Lake, where the most abundant material discharged at about this time has taken the form of a dolerite. It is likely, however, from the close connection of this rock with the succeeding Tranquille beds, that it was poured forth only toward the end of the earlier period of activity. From the beginning of the Tertiary eruptions till their close, though the eruptions were doubtless more or less irregular and spasmodic, the accumulation of materials of volcanic origin in the plateau region probably never entirely ceased. The occurrence of water-bedded rocks, composed almost altogether of rearranged volcanic débris, indicates the formation of lakes which endured for considerable lengths of time, and the blocking up of the old drainage channels of the country by the lava-flows or other volcanic products, may to a great degree if not entirely, explain the impounding of these waters.

Tranquille beds.

There was, however, apparently, one such very notable interlude, of which the water-arranged deposits are believed to be recognizable over a wide area. To the deposits then formed, the name of *Tranquille beds* has been applied. They are largely developed in the vicinity of Kamloops Lake, particularly near the mouth of the Tranquille River, and the persistent zone of stratified tuffs met with on the Nicola River, is believed to pertain to the same horizon. Volcanic action was not entirely quiescent during the formation of these beds, for they include much material which appears to represent volcanic ash, while they are often found to graduate almost insensibly into tuffaceous gglomerates. That the time represented by these deposits was

of some duration, is shown by the fact that they include thin beds of coal near Kamloops. Other localities in which beds supposed to be referable to this horizon are found, are mentioned in the succeeding descriptive portion of the report.

Second volcanic period.

To this important lacustrine episode, succeeded a second great period of volcanic action, of which the products are in the main basalts and basalt-breccias, with smaller quantities of melaphrye, mica-trachite, mica-andesite, etc., and some porphyrites and other rocks resembling those of the first period. The old volcanic foci of the Clear Mountains have suffered so greatly from subsequent erosion, that it is not possible to decide to what extent they may have supplied the material of these later eruptions, though basaltic flows are still found patched upon their slopes at considerable elevations and sometimes lying at inclinations which appear to descend from their axis. It is in fact probable that much of the basaltic material was ejected from minor and less regularly aligned vents or fissures, scattered over various parts of the Interior Plateau. The Kamloops Lake vent, of which Battle and Cherry bluffs represent basal remnants, was evidently one of the more important local sources of the basalts. This is indicated by the thickness of the basaltic agglomerates in its vicinity, the large size of their component fragments, and the quaquaversal dips still found to characterize them. Similar circumstances, though less pronounced than in this case, indicate that Porcupine Ridge, as well as one or more places in the Arrowstone Hills were also centres of basaltic eruption, while there were probably many lesser sources.

Centres of eruption.

Relations of deposits.

There is no evidence such as to show that any prolonged period of rest occurred in the course of these later eruptions. Neither is there any direct evidence of orogenic movement between the first period and the second period of great volcanic activity; for although it is true that the older volcanic products are now more frequently found resting at comparatively high angles of inclination, this may in part be due to the original slopes upon which they were deposited, in part to the fact that in consequence of much later erosion, they now often occupy the peripheral portions of the volcanic areas, where they are in contact with the old rocks, and where whatever flexure has occurred is always found to be greatest. In any case, much the greater part of the area now occupied by the basalts is characteristically flat and undisturbed, or inclined at slopes so light that it is very difficult to tell to what extent these may be original and to what extent superinduced.

Thickness.

The thickness of the upper, or preponderantly basaltic part of the Tertiary, in the vicinity of Kamloops Lake is about 3000 feet. In

the Nicoamen Plateau about 3100 feet; but in many other places and over great areas of the map, these rocks form a comparatively thin and uniform covering of the surface of the plateau, consisting of wide-spread flows, with which little agglomerate is associated.

Changes in the Pliocene.

When this second epoch of great volcanic activity ended, the great later Tertiary period of denudation and erosion began. The Interior Plateau ceased to be an area of deposition and became one of waste. It is, nevertheless, probable that the volcanic forces died out slowly, for some subordinate basaltic flows appear to have occurred after certain valleys had again been cut out to a considerable depth. Possibly some of these later flows may be more correctly referable to the Pliocene, but no sufficient evidence of this has yet been found in the southern part of British Columbia.

Pliocene deposits.

Some fragments of evidence have been found in the area of the Kamloops sheet, such as to show that about the time of cessation of the main period of basaltic eruption, or perhaps at a somewhat later date, but antecedent to the glacial period, lakes were again formed over certain parts of the surface, and that in these a certain amount of sedimentation occurred. These lakes were, however, doubtless small, and as compared with those of earlier dates, transitory; for it is probable that before the great erosion of the latest stages of the Tertiary advanced far, the surface became supplied with a completely developed drainage system.

On the upper part of Hat Creek, where conglomerates chiefly composed of basalt pebbles occur, and again on the south-west slope of Pavilion Mountain, the deposits of such newer lakes are believed to be represented. In fact, the contour of the country and the elevation of these deposits at the two places, is such as to show that they may be attributable to a single lake, though some twenty miles apart.

If the later covering of drift deposits could be stripped from the surface, it is very probable that more beds of the kind just mentioned would be found in some of the valleys, but the instances cited are the only ones so far met with. On the assumption that the main period of vulcanism closed about the end of the Miocene, such later lake-basins must be referred to the early Pliocene; but the history of the Pliocene or latest period of the Tertiary is written almost exclusively in erosion. It was a time of waste, in which the land stood high, and during which nearly all the existing river-valleys of the Interior Plateau were carved out.

Pliocene denudation.

Probably many remnants of deposits due to this period of denudation, and of the nature of river-gravels left behind on terraces or in

sheltered nooks of the larger valleys still remain, but they must be, as a rule, now entirely concealed by the later glacial deposits, from which it would moreover be difficult to separate them in many cases. But a single apparently definite instance of such deposits has been met with in the area here treated of. This is a small patch of coarse river-gravel, now hardened into a conglomerate, which remains on the east side of the Fraser Valley near the mouth of Fourteen-mile Creek. Since the time of its deposition, the river has cut down its valley by about 1000 feet.

Probable age of Tertiary.

Attention has so far been directed merely to the composition and relative order of the members of the Tertiary system within the area of the Kamloops sheet. A few words may now be added with reference to what little is known of their actual age and the positions they may be assumed to hold in the geological scale.

Fossils.

Nearly the whole of the fossils which have been collected from the Tertiary of various parts of the interior of British Columbia are the remains either of plants or of insects. The greater number of such fossils so far obtained from any part of the southern portion of the interior, are derived from localities in the Similkameen Valley, near the confluence of the Tulameen. These localities are parts of a single Tertiary basin which has not yet been traced into connection with any other, and which may have been originally a distinct lake. It lies nearly fifty miles beyond the southern edge of the Kamloops sheet, and is now included in the drainage-basin of the Columbia River.

Comparison with Similkameen beds.

What has been said with regard to the existence of two well marked horizons of stratified deposits within the area of the Kamloops sheet, and in respect to the causes to which these are due, appears to render it probable that the Similkameen beds may correspond in time with one or other of these horizons, and their appearance and mode of occurrence accords best with the hypothesis that of these two they represent the lower or Coldwater horizon, but for the present this correlation stands merely as a probable conjecture.

Oligocene fossils.

In a review of the Tertiary flora of the region, which has been described by him, Sir J. Wm. Dawson finds reason to believe that the Similkameen plants are referable to the Lower Miocene or to the Oligocene.* Of nineteen species of hemipterous insects found in the Tertiaries of British Columbia, sixteen come from the Similkameen localities, and although all the species but one are new, their general facies is, according to Dr. S. H. Scudder, rather indicative of an Oligocene age,

* Trans. Royal Soc. Can., vol. VIII., sect. IV., p. 90.

although some elements of the fauna show relations to that of Radoboj, which is regarded as Middle Miocene.* Lastly, among a few poorly preserved remains of fishes which have been submitted to Prof. E. D. Cope, one from the Similkameen has been recognized as an *Amyzon*, and is regarded by him as showing the equivalency of the beds with the "Amyzon beds" of Oregon.† The age of the Amyzon beds Prof. Cope supposes to be Oligocene, although again in this case with some doubt.

In the Coldwater beds, at the mouth of the river of the same name, a few insects have been found, but these are all Coleoptera and all distinct from Similkameen species, while they are insufficient in themselves to afford any criterion of age.

General Tertiary sequence.

As a result of the determinations above referred to, it may, I think, be fairly concluded that the Similkameen beds are probably of Oligocene (later Eocene) age, and there is a good deal to be said in favour of the belief that the Coldwater beds and their equivalents in different parts of the Kamloops sheet hold the same position. In this case, the probable unconformity between the Coldwater group and the earliest of the overlying volcanic deposits, would mark the close of the Eocene for the region, while the great volcanic accumulations, with the Tranquille intercalation, and perhaps some other similar intercalations, would represent the Miocene period as a whole. Above these come the scanty traces of Pliocene sedimentation already referred to.

A provisional scheme of the Tertiary rocks met with in the Kamloops sheet may therefore be drawn up as follows :—

Tertiary deposits.

	Feet.
Early Pliocene—	
Beds of Upper Hat Creek and N. part of Pavilion Mountain.......	——
Later Miocene—	
Upper part of great volcanic series.—Widely spread over the region. —Greatest thickness, between Nicoamen and Nicola (about)....	3,100
Tranquille group.—Chiefly volcanic materials arranged in water. Tranquille, Nicola valley, etc. Greatest thickness (about).....	1,000
Earlier Miocene—	
Lower part of the great volcanic series.—Nicola valley, Clear Mountains, Kamloops Lake, etc. Greatest thickness, apart from centres of eruption (about)....	5,300
Oligocene—	
Coldwater group.—Near confluence of Coldwater and Nicola, Copper Creek, Hat Creek, etc. Greatest thickness on Hat Creek (about)	5,000
Total.........	14,400

* Contributions to Canadian Palæontology, vol. II., p. 6.

† Proc. Acad. Nat Sci. Philadelphia, 1893, p. 401.

Plutonic Rocks.

How distinguished on the map.

The plutonic or intrusive rocks generally, are included under the pink colour on the map. Of these the greater part may be classed as true granites, but considerable areas of dioritic rocks also occur, with some of gabbro. Our knowledge of these rocks in this district is as yet insufficient to enable the several classes to be separately indicated on the map. This must, indeed, always remain a very difficult task in some cases, for a passage of granitic rocks into diorites may often be noted, particularly about the margins of the granitic areas, where these appear to have absorbed large portions of the more basic materials of adjacent old volcanic rocks of the stratified series. As elsewhere explained, a similar practical difficulty has been found in drawing any exact line between some of the granites and the gabbros and mica-diorites of the Cherry Bluff mass.

Age of granitic rocks.

All the rocks thus grouped together bear very similar relations to the stratified rocks of the district, having altered and otherwise affected those among which they have been intruded. They are, however, not all of one age. The larger granitic masses of the Coast Ranges and of the Interior Plateau are evidently due to a period subsequent to that of the Nicola (Triassic) formation and antecedent to that of the Earlier Cretaceous. In this respect they agree with the great granitic masses which have been studied on the outer margin of the Coast Ranges along the Pacific border of British Columbia.* They are probably coeval with these and due to the same orogenic causes.

The Cretaceous rocks are, however, also in some places broken through by granitic masses, rendering it evident that a portion of the granites must be much more recent in date. Granites of this age may occur in many places where the absence of the Cretaceous rocks renders it impossible to determine their age, for no means has yet been found of differentiating these granites petrographically from those of the earlier period.

It is also certain, that granitic rocks due to periods much earlier than the Triassic must occur in some parts of the region, for even in the Cambrian strata, rocks largely composed of granitic débris are found (p. 108 B). Some of the gabbros and diorites again, are believed to represent the deep-seated products of the Tertiary period of volcanic activity.

Notable hornblendic zones.

Perhaps the most notable fact which appears on assembling the numerous observations made, is that of the existence of two zones in

* Annual Report, Geol. Surv. Can., vol. II. (N.S.), p. 15 B.

which highly hornblendic rocks, often true diorites, are specially prevalent. The first of these runs near to and parallel with the Fraser River, though generally on its east side. It may be regarded as including a great part of the Lytton Mountains, Botanie Mountain and its northern continuation, the plutonic rocks met with between the vicinity of Fountain and Pavilion Creek and those found near Leon Creek. The second zone of the same kind, runs nearly parallel with the Nicola and part of the Thompson River from the Promontory Hills to the vicinity of Ashcroft.

Their probable origin.

The first of these zones is undoubtedly connected at no great depth with the truly granitic rocks of the Coast Ranges on the west, the second blends to the eastward with the large mass of true granites which occupies the area between the Nicola and Guichon Creek. In the first, numerous cases occur where the intrusive material is inextricably mixed with much-altered greenstones and other bedded rocks, while infolds and lenticular masses of now crystalline schists, (some at least of which doubtless represent bedded materials) are abundant in it. In the second, these conditions are not so clearly apparent ; but in both, it is probable that the present character of the rock is largely due to the absorption, or granitic fusion nearly in place, of great masses of the basic materials of the older formations. In some other instances, the plutonic rocks are clearly eruptive, sharply defined and quite different in character from the older materials which they break through, while many cases of an intermediate character present themselves, where no sound judgment appears possible as to the relations in this respect of the two classes of rocks.

Peripheral effects of pressure.

It is very generally observed, that the borders of the areas of granitic and other plutonic rocks, afford evidence of intense pressure, both in the foliation imparted to these rocks themselves and in the effects produced in the neighbouring stratified rocks, one of which is a tendency to parallelism of the strike of these rocks to the line of junction. This is not only the case in the strictly folded region of the Coast Ranges, where both classes of rocks appear to have been subjected, perhaps at several periods, to a common compression, but also in that of the plutonic masses of the plateau region, where the evidences of a general compression are much less distinct. Whether these peripheral effects are due to a pressure exerted by the plutonic rocks themselves, or whether the extrusion or granitic fusion to which such rocks must be attributed relieved a formerly existing pressure when it occurred, the facts appear to be insufficient to decide.

In later pages such brief details as appear to be necessary are given for the several plutonic areas. The clearly apparent fact that the development of veins holding metalliferous minerals is largely dependent on proximity to such areas and the hydrothermal or other similar action which has been set up during the formation or intrusion of these masses, renders their definition a matter of some economic importance. It is, further, highly probable, that when the metalliferous veins are better known and more extensively worked, it will be found possible to trace differences in their character dependent on the differing composition of the various crystalline masses near them. Connection with ore-bearing veins.

Intrusive rocks of the character of dykes, occur in great numbers in many parts of the entire region, and in almost endless variety in respect to composition; but in the present preliminary state of our knowledge of the region, it is judged to be unnecessary to detail observations upon these rocks or to enter at any length into the examination or description of them. At some future period a study of these dyke rocks may be undertaken, which may not be without results of importance, but, in common with many other detached lines of investigation, it has been found necessary to relegate this to later observers. Dyke rocks.

DESCRIPTIVE GEOLOGY.

In this division of the report, such local details as appear to be of importance are given, and the data relied upon in laying down the geological lines in different parts of the field are discussed. The observations referred to are generalized as far as possible, but they are required in order to supplement the broad indications afforded by the map. The order of description adopted is not strictly that of relative age throughout, as it is more convenient to arrange the matter in some cases in correspondence with locality. Generally speaking, however, the Palæozoic rocks are first noticed, and these are followed by the Triassic, the Cretaceous and the Tertiary; rocks classed as Plutonic coming last. The drift deposits or Pleistocene are noticed in a subsequent chapter. Order of treatment.

Palæozoic Rocks.

Thompson Valley—In-ki-kuh Creek to Câche Creek.

Rocks referred to the Câche Creek formation, are first met with in ascending the Thompson Valley about six miles above Spence's Bridge, Disturbed rocks on the Thompson.

where they emerge from beneath the Miocene volcanic materials and occupy a narrow interval between this and the great granite mass to the eastward. They occur on both sides of the river, and numerous exposures may be found, but all are so much broken and disturbed that nothing can be said with certainty as to their general arrangement. The main direction of strike is about N. 20° W., and most of the observed dips are to the westward; it is therefore probable that the higher beds occur in that direction. There is reason to believe that faulting has occurred along the line of the Thompson or that of Venabels Valley, and perhaps in both places.

Fossiliferous limestone.

The rocks consist of gray limestone, with greenstones, sometimes more or less schistose, cherty quartzites, which often show locally an extreme stage of alteration and shattering, and hard, black slaty argillites. The bed of limestone which appears on the wagon-road two miles and a half above the 89-mile stable, is that particularly referred to in Dr. Selwyn's original report, from which some fossils were at the time collected by Mr. Richardson. Among these the following genera were recognized:—*Cyrtina*, *Spirifera*, *Rhynchonella*, a small *Myalina* and a *Euomphalus*. Respecting these Mr. Billings wrote:—"Although none of the above have been determined specifically, they indicate almost certainly a horizon between the base of the Devonian and the summit of the Permian."*

Venables Valley.

Along Venables Valley, greenish, somewhat schistose rocks, with gray and blackish argillites were found. These appear to underlie massive limestones, which occur in the hills on the west near the head of Twaal Creek and in White Mountain.

Shattered and decomposed rocks.

In following the wagon-road northward, the rocks all along this part of the Thompson Valley are found to be excessively shattered and decomposed. Red, yellow and white crumbling banks often appear in gullies and on hillsides, composed of rocks which have been completely crushed and often pyritized or silicified. Later hydrothermal or solfataric action, resulting in the decomposition of the pyrites and the leaching of the mass by acid waters, has given rise, opposite Spatsum station, to a deposit of china-stone with kaolinite and gypsum, which is again referred to in connection with the economic minerals of the district.

China-stone.

Pyritized rocks with traces of gold.

To the north of Jack's Creek, similar alteration has affected the rocks on both sides of the road. On the east, the Red Hills show crumbled quartzites highly charged with pyrites. On the west, the crushed

* Report of Progress, Geol. Surv. Can., 1871-72, pp. 61-62.

rocks extend for nearly two miles and appear to be composed largely of quartzites, or at least of rocks now so highly silicified that they resemble quartzites. As noted on a later page a specimen of these rocks proved to contain traces of gold. With these are quartzose schists, often quite lustrous, but some of which still evidently represent fragmental materials like some of those found in a less altered condition in association with the limestones near the 89-mile stable. These rocks are here in general nearly vertical, with a north-north-west strike, and they have evidently been subjected to great pressure in a direction at right angles to the strike. They are probably folded, but it is impossible to trace out individual beds for any distance.

The edge of this greatly disturbed belt of rocks is found at this place at or near the small granitic intrusion shown on Jack's Creek. To the west of this, the beds are comparatively undisturbed, and it is highly probable that one or possibly several faults, running about north-north-west along this part of the valley, coincide with this change in condition. Edge of disturbed belt.

The zone of greatly disturbed and altered rocks above described, runs parallel with this part of the Thompson for fifteen miles or more, generally to the west of the river. The dynamic forces which have acted upon the rocks have in some places produced schists, while in others, and generally more or less lenticular areas, the strata have become crushed and comminuted.

Twaal and Blue-earth Creeks.

The hills about the sources of Twaal Creek and those along the north side of Blue-earth Creek, are almost exclusively composed of limestone. In the last mentioned locality, gray limestone which is in part converted into marble, forms bold whitish cliffs facing southward, much resembling some of the cliffs along Marble Cañon. The openings of several caves or grottoes were observed high up in these cliffs. At the lower end of the little lake in which Blue-earth Creek rises, gray, probably concretionary chert is associated with the limestone, and in this there occur many specimens of *Loftusia* with some *Fusulina*, beautifully preserved. Extensive limestone exposures.

At the mouth of Blue-earth Creek, the limestones are found to dip westward at high angles. They run thence to the north, along the Hat Creek valley, still forming bold cliffs to the entrance of the pass which leads eastward by way of Jack's Creek to the Thompson. At the entrance to this pass, on Hat Creek, the limestone was again found to Section along Jack's Creek.

dip westward, at a very high angle. Beginning at this place it was endeavoured to obtain a general section across the range of hills to the Thompson Valley, but with unsatisfactory results. The rocks seen are chiefly limestones, but, where their attitude could be ascertained, they appear to lie generally at low undulating angles, in such a manner that no great thickness is brought to the surface. With the limestones are interbedded hard, fine-grained, green, felspathic rocks, some of which are much decomposed diabase-porphyrites.* These are sometimes slightly schistose in structure and usually very much slickensided. There appear to be at least two important beds of this kind, one of them probably 300 or 400 feet thick, the other forming the lowest rock seen, but only in part exposed. Black schistose argillites and cherty quartzites were also seen, but not in great volume. Rocks of this kind were particularly noted near Limestone Amphitheatre, and again near the small granitic intrusion to the eastward, and between these places the beds appear to have the form of a shallow syncline about two miles in width. Some cherty masses occur in the limestones themselves, and in these crinoidal remains have been preserved.

To the east of the granitic intrusion just mentioned, the much altered rocks of the Thompson Valley begin, as previously explained (p. 81 B). Limestone cliffs are characteristic of the north side of this valley as of that of Blue-earth Creek, and at the Amphitheatre they assume remarkably picturesque forms.

Medicine Creek, McLean Lake, Cornwall Creek.

Cornwall Hills and vicinity.

Continuing to the northward, the older rocks observed in a few places to the east of the Tertiary of Hat Creek and south of Medicine Creek, are chiefly gray limestones, with some diabase-like green rocks resembling those last described, and occasional exposures of cherty quartzite. The dips are generally high and varied in direction.

The summit of the Cornwall Hills (6600 feet), was reached by ascending from Jack's Creek along the ridge overlooking the Thompson Valley. The higher part of the hills is open sub-alpine country, with numerous bare limestone outcrops and some minor exposures of greenstone and cherty quartzite. These rocks as a whole are probably about the horizon of the base of the Marble Cañon limestones.

North of Medicine Creek.

North of Medicine Creek, between the two areas of Tertiary shown on the map, green altered diabases, sometimes agglomeritic, with

*Appendix I., No. 6.

cherty quartzites, were the only rocks actually seen, but limestones may not improbably also occur here. The strike is pretty constant at about N. 40° W., and the beds are nearly vertical. The interbedding of the greenstones with the quartzites was clearly seen at one locality.

In the vicinity of McLean Lake, the older rocks consist, so far as observed, chiefly of greenstones, probably diabase in composition, and gray limestones. The attitudes of these rocks are rather irregular, but a nearly east-and-west strike is found in some places. A mile and a half south of McLean Lake, quartzite-schist and greenstone agglomerate were found, the latter containing numerous limestone fragments and some circular crinoid joints. One of these was observed to be over three-quarters of an inch in diameter. The hills separating the Cattle Valley from that of the Bonaparte, are likewise composed chiefly of limestones and interbedded greenstones, the latter being often more or less distinctly schistose. The strike is here on the average, about N. 35° W., with high south-westerly dips. McLean Lake.

The limestone areas shown upon this part of the geological map have not been strictly defined. It would be very difficult to accomplish this here, and the intention is merely to indicate the existence of large bodies of limestone. The horizon is again, in all probability, about that of the base of the Marble Cañon limestones.

In following down Cornwall Creek, from McLean Lake, after a concealed interval of a couple of miles, the rocks seen are principally cherty quartzites, with some fine-grained greenstone and a bed or beds of serpentine. A rather prominent little hill of gray limestone occurs on the north side of the stream before the wagon-road is reached. The surrounding rocks are cherty quartzites and quartzite-schists, but the whole so irregular and so much broken up that the order or relations of the several rocks could not be determined. Cornwall Creek.

Câche Creek to Mundorf's.

Between the western edge of the Ashcroft Cretaceous area and Mundorf's, on the wagon-road, a distance of some fifteen miles, the general strike of the rocks, which is about north-north-west, carries them obliquely across the line of the Bonaparte River and that of the wagon-road. This general strike is, however, subject to numerous subordinate irregularities, while the angles of dip met with are very varied, and it has so far proved impossible to define, with any accuracy, either the thickness of the strata met with or their general succession. It is thus necessary to describe these rocks as a whole and in general terms. It General run of the rocks.

would appear that numerous smaller folds are here superposed on the main flexures of the beds, and that there is thus a tendency for each zone of rocks, to occupy occasionally, a narrow or wide belt of country, in such a manner that the actual thickness could only be ascertained (if at all) by a most minute survey of the whole area.

Cherty quartzites.

The most characteristic material is here a cherty quartzite or silicified argillite, which is generally found in thin beds of blackish or gray colour. These are separated by black, more or less lustrous argillite-schists, or by gray, glossy schists; and with them are interbedded one or possibly two beds of green or blackish serpentine. These rocks appear to cross the Bonaparte with a north-westerly strike to the north of the small outlier of Tertiary rocks marked on the map and described on page 213 B. Further west, they gradually turn to a north-eastward direction near Câche Creek, where they are much disturbed and corrugated. They next assume a north-north-westerly strike, and with dips which are in the main to the westward, cross the Bonaparte above the Indian village and occupy the lower part of the valley of Hat Creek between the river and the fault which here appears to bound the older Tertiary rocks to the eastward. The thickness of the rocks included in this belt, chiefly cherty quartzites, may be stated as probably from 4000 to 5000 feet. To the westward, near the Tertiary outlier above alluded to, and on the western slopes of the hills near Campbell Hill and declining to the Cattle Valley, the cherty quartzites and their associated rocks are followed, and apparently overlain, by interbedded green and green-gray diabases and limestones, in beds of small or medium thickness, which are carried by their strike beneath the older Tertiary rocks.

Conglomerate.

At five miles and a half below Hat Creek, about half a mile west of the wagon-road in the Bonaparte Valley, some exposures were found of a peculiar coarse greenish-gray conglomerate holding rounded pebbles. This rock has suffered considerable metamorphism, and appears to have been included in the flexures of the older rocks, but, as it holds some cherty quartzite pebbles, it may represent an outlier of some newer bed—possibly referable to the Nicola formation.

Rocks probably overlying quartzites.

For about two miles to the north of Hat Creek, on the west side of the Bonaparte, the hills continue to be chiefly composed of the cherty quartzites. Beyond this point, to Mundorf's, the character of the rocks becomes more varied, and they are, in all probability, referable to a somewhat higher stage in the formation. As no persistent attempt to work out the stratigraphy in detail has yet been made, the rocks as a whole may be described in the following general terms, quoted from my report of 1877 (p. 93 B):—

"Between Hat Creek and 124-mile post (Mundorf's) numerous exposures in the roadside show the intimate association and inter bedding of the cherty siliceous rocks with serpentines, pure and impure, and of the latter with volcanic breccias of greenish-gray colour. Some of the fragments in the breccias are from four to six inches in diameter, while in other beds the material is fine, and must originally have been of the character of volcanic sand. Schistose layers in the breccias have a greasy lustre, and appear to have more or less serpentine developed in them, while portions of the fragments which have been vesicular are now filled with soft green chloritic matter. An igneous rock similar to that forming the breccias is found in other beds in a compact state, of dark gray-green colours. * * * Lenticular masses and streaks of limestone occur, both in the breccias and serpentines. They do not resemble the limestone found elsewhere in the formation, being highly crystalline, and without any trace of organic origin. They may probably have been segregated in the mass." Between Hat Creek and Mundorf's.

About two miles and a half above Hat Creek, for a width of nearly half a mile, the rocks are very much shattered and decomposed, crumbling down into yellow and red banks, in consequence of the oxidation of iron pyrites with which they have been charged. Crushed rocks.

On the opposite side of the Bonaparte, in this part of its length, a rather important outcrop of limestone occurs. This crosses Scottie Creek a short distance above its mouth, with an arcuate form, convex toward the river. It is prominently seen in the hills to the north of this creek, where it is separated from the river by outcrops of gray schists and quartzites, which, though they present somewhat confused and varying attitudes, probably underlie the limestone horizon. Limestone

Bonaparte Valley above Mundorf's, and Glen Hart.

At Mundorf's, the main wagon-road leaves the Bonaparte and follows Glen Hart to Clinton. In the valley of the Bonaparte, northward to the Chasm, where it becomes occupied by Tertiary volcanic rocks, beds of the same character with those just described continue. Along this part of the valley, which is about thirteen miles in length, there appears to be a reasonably good opportunity of working out a general section of the strata represented, which are evidently referable to the same part of the Câche Creek formation with those to the south of Mundorf's; but, so far, little has been added to the results of the preliminary examination of 1877. Cherty quartzites of the usual character preponderate, often with blackish or gray shaly partings Bonaparte Valley.

between their bedding planes. With these are interbedded greenstones, often agglomeritic, together with gray ash rocks, now more or less schistose, limestone beds and serpentines. The serpentine bed (or beds) is evidently most closely associated with the rocks of volcanic origin, and is no doubt derived from the alteration of some volcanic rock. The strike is in the main north-west by south-east. The subjoined section, sketched at a place two miles above Loon Creek, and which appeared in the report for 1877, is reproduced here because of its interest in connection with the mode of occurrence of the serpentines of this formation. The bed of serpentine here represented is about 100 feet in thickness. No characteristic fossils were found in the particular bed of limestone included in the section, but about a mile further down the river, in another outcrop which may possibly represent the same bed, good specimens of *Fusulina* were discovered. This outcrop is associated with altered volcanic rocks but no serpentine was actually observed. The mass of the limestone is largely composed of crinoidal fragments, and several smaller species of foraminifera are present, including a form which is in all probability a *Trochammina*.

Occurrence of serpentine.

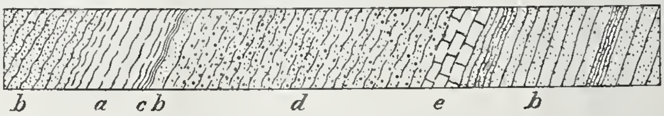

FIG. I. SKETCH SECTION SHOWING THE MODE OF OCCURRENCE OF SERPENTINE IN THE CÂCHE CREEK FORMATION.

a. Serpentine. *b.* Quartzite. *c.* Pale serpentinous schist. *d.* Greenish amygdaloid and breccia. *e.* Limestone.

Mundorf's to Maiden Creek.

In following the road from Mundorf's through Glen Hart, toward Clinton, the rocks continue to resemble those above described, about as far as the mouth of Maiden Creek; greenstones and cherty quartzites being most abundant. Thence northward, their character becomes somewhat changed. A schistose or slaty structure is in most cases observable, while very thin and flat divisional planes are developed. These as a rule correspond with the original bedding planes of the rocks, which are frequently still recognizable, but to which the schistose structure has been superadded by subsequent stress. The dips are here also found to be at very moderate angles of inclination, and while the valley as a whole follows the strike of the beds, this occasionally turns abruptly to bearings almost exactly transverse to the valley. The rocks consist chiefly of gray and greenish schistose materials and of black glossy argillites. The gray schists are evidently composed of squeezed volcanic ashes, while the greenish schists are clearly an alter-

Schistose rocks in Glen Hart.

Origin of the schists.

ation-product of the ordinary greenstones or diabases; but along this part of the valley the cherty quartzites before so common, were not seen. The black glossy argillites precisely resemble those found along the Bonaparte Valley, and in regard to the gray schists, a less squeezed material of the same kind, and more evidently clastic, was found to occur about a mile below Mundorf's, in the Bonaparte Valley.

The problem presented by the rocks here met with, is whether they represent a peculiar condition of alteration of materials of the same age with those already described, or whether they may belong to a different and an older series, for, if it be admitted that their present appearance is of classificatory value, they very closely resemble lithologically certain rocks found along the Fraser River (particularly those in the vicinity of Anderson River and Boston Bar, to the south of the Kamloops sheet) which were originally assigned to a very low stage in the Palæozoic. So far as I can see from our present knowledge of the subject, no reason can be urged for the supposition that these particular rocks are older than the rest. It would appear that they have been to a great extent exempted from the silicifying changes which has resulted in the production of the cherty quartzites from ordinary argillites, while they have been instead affected by pressure, giving rise to a dynamic metamorphism, which in all probability occurred at an earlier period than the silicification. Probable relations of these rocks.

At the north end of the little lake situated about a mile to the south of Round Lake, a bed of gray crystalline limestone about thirty feet in thickness occurs, and is interbedded in schistose rocks of the character just described.

In ascending Hart Ridge from Clinton, rocks like those of Glen Hart are occasionally seen, though the surface is much covered by drift. Along Junction Valley, from Clinton to the Bonaparte, the rocks seen are chiefly quartzites and greenstones, resembling those of the Bonaparte, and offering no features of special interest. Hart Ridge

Marble Cañon and Vicinity.

In the report for 1877, an attempt was made (in section No. 5), to give a diagramatic representation of the relations of the rocks occurring between Lillooet, on the Fraser River and the mouth of Hat Creek on the Thompson, via Marble Cañon. Subsequent investigations show that some of the features represented in the western part of this section require modification, particularly in respect to the now recognized Tertiary age of the porphyrite rocks, which Section 1877.

in 1877 were supposed to be attached to the Cretaceous series, but in the main, that part of the section which runs eastward from the west end of Marble Cañon, is still believed to afford a general idea of the structure. A short description of the older or Câche Creek rocks shown in the Marble Cañon section, from the Fraser at the mouth of Pavilion Creek eastward, will therefore here be given, based in part on that contained in the report of 1877, with the omission of some details which may not require repetition and with the addition of some new facts since ascertained.

Mouth of Pavilion Creek.

From the fall, near the mouth of Pavilion Creek, for a distance of about three miles and a half eastward, or to about a mile beyond the bridge crossing Pavilion Creek, the rocks may be described as consisting chiefly of hard green or gray-green altered diabases, of rather fine grain. With these rocks, a short distance above the fall, a couple of thin limestones are interbedded and some thin layers of quartzite, all very irregular. One of the limetones is again found to the southward, about half-way between Pavilion Creek and Eighteen-mile Creek, on the road.

Intermingling with diorite.

In the hills between Eighteen-mile Creek and the south side of Pavilion Creek, these rocks are very largely mingled, in a perplexing manner, with greenish granitoid diorite. A careful examination of the rocks, appears to show that in this place the plane of the present surface nearly coincides with that of the upper part of an intrusive mass, or that of a centre of alteration, where the diabase-like stratified rocks are everywhere penetrated by apophyses of a dioritic character and have been perhaps in the process of fusion with such a crystalline rock. The circumstances are in fact such, that it is often impossible to draw a definite line between the altered stratified materials and those classed as eruptive. The area thus characterized is specially designated on the map.

Half a mile above the bridge on Pavilion Creek, another projection of highly altered and confused rocks like those just described, crosses the valley. This is about half a mile wide, and the dioritic material becomes predominant in its eastern part. Beyond this, for a mile, the rocks are gray cherty quartzites, silicified argillites and black argillite-schists, all considerably crushed and often weathering rusty. These appear to strike across the valley almost at right angles and are generally vertical or very nearly so.

Cherty quartzites.

Granitic intrusion.

A short distance east of Captain Martley's house, the section is interrupted by a granitic intrusion, which holds angular fragments of

the stratified rocks in some places, and extends for about two miles along the valley, surrounding the lower end of Pavilion Lake.

Massive limestones.

This granite is followed by hard, somewhat lustrous and schistose argillites, which are cherty in some layers and dip N. 75° E., at angles of 70° to 80°. The thickness of these rocks to the east of the granite is not very great. They are succeeded, apparently in ascending order, by a great mass of limestone, which continues in almost uninterrupted exposures in the sides of Marble Cañon from this place to its eastern end, on Hat Creek—a distance of about seven miles by the valley, or five, at right angles to the strike of the beds. Throughout this distance the limestones occur almost to the exclusion of other beds, though in a few places holding slaty or schistose intercalations of small width. The limestones or marbles, into which they occasionally pass, are usually so massive that it is impossible to determine their dip, but that they are much folded together appears to be certain. An example of such folding, in which a small acute anticline comprising some slaty beds and quartzites has been overturned to the eastward, is figured and described in detail in my report of 1877 (pp. 90 B-91 B). This occurs in the front of the hill on the north side of the east entrance to Marble Cañon, close to Hat Creek.

Their flexures.

Loftusia and Fusulina.

In the limestones of Marble Cañon, Mr. James Richardson, in 1871, collected specimens containing the remarkable Foraminifer which was subsequently described by me under the name of *Loftusia Columbiana*.* The microscopical examination of numerous thin sections of the limestone, led also to the discovery of characteristic specimens of *Fusulina*, rendering it probable that the *Loftusia* may be accepted as equally characteristic of a Carboniferous age. Besides the above forms, no recognizable fossils except the joints of crinoidal columns, have been obtained from these massive limestones.

Character of *Loftusia* limestone.

In regard to the mode of occurrence of the *Loftusia* and its importance as a limestone builder, the following extract may be quoted from the paper last above referred to:—

"In certain beds of the limestone of Marble Cañon, the *Loftusia* occurs almost to the exclusion of other forms, characterizing the rock, and having been the agent in its production, just as *Fusulinæ* occur in the best examples of *Fusulina* limestone or Globigerinæ in the Atlantic ooze. Other beds of a nearly white colour and almost porcellanous aspect on fracture—though purely calcareous—are found on miscroscopic examination to consist of the comminuted remains of

* Report of Progress, Geol. Surv. Can., 1877-78, p. 88 B. Quart. Journ. Geol. Soc., vol. XXXV., p. 69.

smaller Foraminifera, the mass resembling a thoroughly hardened chalk. Through these a few more or less perfect *Loftusiæ* may be scattered. *Fusulinæ* appear to be very scarce in the Marble Cañon limestones ; they are much more abundant in those of other parts of the country, composed principally of crinoidal fragments. They seem to have preferred a bottom composed of the débris of the larger calcareous organisms to the fine oozy bed most congenial to the *Loftusia*."

"The typical and most abundant form of *Loftusia* limestone is a pale or dark gray crypto-crystalline rock, in which the more perfect specimens of *Loftusia* appear thickly crowded together as paler spots, generally pretty sharply defined. The limestone breaks freely in any direction, the fracture passing equally through the matrix and included organisms, which it is impossible to separate from the stone. The matrix generally seems to be composed in great part of granular calcareous matter similar to that employed in building up the test of the *Loftusia*, but more irregular in size of grain, and with an occasional fragment of a Crinoid or example of smaller Foraminifer."

East edge of limestone belt.

In following down the valley of Hat Creek, in a north-easterly direction from the eastern end of Marble Cañon, similar limestones are found to continue for about three miles, or till they become covered by the Tertiary rocks in that direction. The limestones here include at least one bed, which must be over a hundred feet thick, of fine-grained gray-green felspathic rock, originally volcanic.

Further down Hat Creek, a small projecting ridge of the older rocks which appears from below the Tertiary conglomerates, is chiefly composed of hard green agglomerate, though to the north of the valley it consists almost entirely of limestone. The cherty quartzites and associated beds met with near the mouth of the creek have already been noticed (p. 84 B).

General arrangement and thickness.

The rocks included in the whole section above described, between the Fraser and the Bonaparte, are believed to hold in the main a synclinal form, though with many irregularities and minor complications. The structure is at least undoubtedly a synclinal one between the Pavilion Creek granite and the main western edge of the Tertiary rocks. Of this the limestones hold the whole central and stratigraphically higher part. Taking the actual distance across the strike, which is pretty uniformly north-north-westward, with the average inclination given by the few observed dips, the thickness of the limestones would appear to be about thirteen thousand feet. But there

is every reason to believe that they are in reality affected by numerous subordinate flexures, and that though very thick, the entire mass may not even reach half the amount stated.

Mount Martley and Chi-pooin Mountain.

The facts ascertained respecting the older stratified rocks in the adjacent mountains, necessarily somewhat imperfect, may now be briefly noted in connection with the Marble Cañon section.

Rocks surrounding granite mass.

The central parts of Mount Martley and Chi-pooin Mountain are composed of a mass of gray granite. To the west of this granite mass, the rocks consist chiefly of cherty quartzites and hard blackish and gray argillite-schists, interbedded with limestone, which preponderates toward the edge of the granite. The quartzites and argillites are evidently continuous with those seen on Pavilion Creek near Captain Martley's house. The strike is about north-and-south, and the beds are vertical, or very nearly so, wherever examined. To the north-east of the granite area, a lower range of hills, composed apparently almost entirely of limestone, separates it from Marble Cañon. Where close to the edge of the granite, near Hat Creek, the limestone was observed to be locally changed into coarse, or fine-grained, gray and white striped and blotched marble; but this is apparently too much broken up to be of any value. Some quartzites and schists were also found interbedded with the marble in this vicinity.

To the south of the same granite mass, on Chi-pooin Mountain and along the north side of Limestone Creek, limestones again preponderate. They are associated with some greenish or blackish diabase-like rocks, and with small beds of black argillite-schist and cherty quartzite. The limestones are altered, as in the case last described, near the actual edge of the granite. They dip southward at high angles.

Dips away from granite.

It will be observed that there is a tendency for the limestones and associated stratified rocks to dip away from the granite in all directions. One very small outlier of marble was found patched upon the granite to the west of the summit of Mount Martley, and it is probable that others of the same kind occur in this high region.

Pavilion Mountains.

Pavilion Mountains limestone.

The southern slopes of the Pavilion Mountains, east of the Pavilion Creek granite, are all remarkably free from drift deposits. They were well seen from several high points, and appear to consist entirely of limestone, though there are doubtless also minor intercalations of

other materials, as elsewhere found. In crossing these mountains by the upper valleys of Pavilion Creek and Maiden Creek, limestone is again found almost to the exclusion of other rocks, though occasional exposures of black schists, cherty quartzite and greenstone also occur. The two last-named rocks were noted to be particularly abundant near the sources of Pavilion Creek and close to the summit of the pass, but the higher hills and larger exposures everywhere consist of limestone, precisely resembling that of Marble Cañon. Tsil-tsalt Ridge, seen only from a distance, where not capped by Tertiary volcanic rocks, appears likewise to consist of similar limestones.

Junction Valley.

The rocks of the eastern part of Junction Valley have already been mentioned in connection with those of the Bonaparte and Glen Hart (p. 85 B). To the west of Clinton, this remarkable valley crosses the direction of the Marble and Pavilion Mountains and the general strike of their component rocks, nearly at right angles. Its western end is occupied by the lower part of Kelley Creek.

Rocks west of Clinton.

For about four miles west of Clinton, the mountains on both sides of the valley are practically wholly composed of limestone, and for a further distance of about four miles, nearly to the point at which the road turns up Kelley Creek valley, the same may be said with regard to the upper parts of the mountains at least. The valley itself is wide, and the exposures seen are few and poor unless the slopes are ascended. In an exposure midway between the forty-fourth and forty-fifth mile-posts from Lillooet, in the valley, scattered specimens of *Loftusia Columbiana* were detected in a gray limestone, which here dips S. 64° W. $<$ 60°. About two miles to the east of Kelley Lake, on the northern side of the valley, a short section, about two miles and a half in length, was carefully examined and measured in 1877, the exposures on the hillside at this place appearing to be more continuous than usual. A note on this section is given in the report for 1877-78 (p. 95 B), but it proved to be impossible to arrive at certainty in regard to the thickness or order of superposition of the beds, because of the great amount of disturbance to which they have been subjected. It shows, however, the intimate association of the massive limestones with blackish to pale-greenish cherty quartzites or hornstones, quartzose and felspathic schists, and greenish or grayish-green decomposed diabases or felsites. Some of the beds are serpentinous in joints and cracks, and small quantities of chrysotile or serpentine-asbestus were observed in one place. The section as a whole is supposed to be near

Disturbance and complication of beds.

the base of the Marble Cañon limestones and very probably about the horizon of that at the east entrance of Marble Cañon (p. 89 B).

To the west of Kelley Lake, the massive limestones are no longer found. About the lake and along the road which ascends the slope of Pavilion Mountain to the south, the rocks consist chiefly of blackish argillites, generally more or less schistose, often considerably silicified, breaking with a rough irregular fracture and weathering rusty. With these are cherty quartzites of the usual kind, in considerable abundance, and at Kelley Lake some greenstone, probably interbedded, was noticed. The general strike of these rocks along the road above referred to, is a few degrees west of north, with westerly dips at angles of from 30° to 70°. Similar rocks continue on the lower part of Kelley Creek, which falls rapidly in a very rough gorge to the Fraser, but cherty quartzites are, perhaps, more abundant here. They are all very much fractured, and near the edge of the Fraser contain a quartz-vein which an attempt has been made to work for gold. This, known as the Big Slide mine, is described later.

Rocks west of Kelley Lake.

Big Slide mine.

Fraser Valley, North of Kelley Creek.

To the north of the mouth of Kelley Creek, a small granitoid mass, about four miles in length, occupies a part of the Fraser Valley, and it will be convenient for purposes of description, to combine the notes made on both sides of the river from this place to that in which the valley enters the map-sheet. This granitoid mass is nearly in line with that found to the south of Pavilion Creek and east of the Fraser (p. 88 B). Its relation appears to be similar to the adjacent rocks, and these are all highly altered in its vicinity. Near its southern end, on the west side of the river, are coarse, almost gneissic rocks, apparently much metamorphosed diabases, hornblendic schists and hard gray quartzite. On the east side of the river, north of Kelley Creek and bordering on the granite, the rocks are chiefly cherty quartzites, but include diabase-like materials which appear to blend with the greenish granitoid mass, and one or more thin beds of limestone. It is impossible here to draw a distinct line between the eruptive and the stratified materials. Rocks precisely similar to those found at the south end of the granitoid mass occur about its north end, on the lower part of Leon Creek, but with the addition of a bed of limestone or marble about fifty feet in thickness.

Granitoid mass and surrounding rocks.

On leaving the vicinity of the eruptive rock, the excessive alteration above noted, ceases. The rocks on the west side of the Fraser, from Leon Creek to the edge of the map, consist chiefly of gray and black

North of Leon Creek.

cherty quartzites, generally in thin and regular beds, with black or blackish schistose, argillites which in some places preponderate over the quartzites. Some greenstones also appear and two outcrops of limestone, in beds of inconsiderable thickness, were noted. One of these occurs two miles above Leon Creek, the other almost exactly where the line of the edge of the map is drawn. The first of these, under the microscope, shows evidences of great pressure, but crinoidal fragments are distinguishable; the second may be called a marble. The strike of the rocks along this part of the valley, is pretty uniformly north-west; the angles of dip are usually high and the beds in all probability form several folds. On the east side of the Fraser, in the corresponding portion of its length, the rocks are precisely similar to those just described, though argillites are perhaps a little more abundant, and some instances of distinct slaty cleavage were observed in these.

Big Bar Creek.

Further to the north and west, beyond the edge of the present map, argillites and quartzites of a similar character, with some diabase and occasional thin beds of limestone, are cut across nearly at right angles by Big Bar Creek. The valley of this stream appears to be a likely place in which to obtain a general section of these rocks.

Valley between Edge Hills and Marble Mountains.

The Edge Hills.

The valley which separates the Edge Hills from the Marble Mountains, has been cut out along the general strike of the rocks and almost exactly on the line of junction of the argillaceous schists and quartzites on the west, with the massive limestones of the Marble Mountains on the east. In the northern part of the valley, the actual junction of the two classes of rocks is covered by basalt, but along the upper part of Kelley Creek, which flows in this valley, the line can be closely traced. The Edge Hills, by which this valley is separated from that of the Fraser, appear to consist entirely of the argillites and quartzites with their associated rocks, as described in the foregoing pages; the western part of Junction Valley, with the Fraser Valley, that of Big Bar Creek and the valley last referred to above, completing the circuit of these hills. To the northward, the trend of the Edge Hills turns more to the west, in conformity with a general change in the strike of the beds.

Haller's Mill.

At the extreme north-western angle of the map, a locality of some interest is found at Haller's mill. A gray fine-grained limestone occurs here, striking about N. 5° W. and dipping eastward at angles of 60° to vertical. The beds are so soon covered by basaltic rocks to the eastward, that it is impossible to tell whether this limestone actually

forms a part of the massive series of limestones appearing in the Marble Mountains, but it cannot be far beneath their horizon. In the gorge of the stream, below the mill, the limestone is, however, found to be underlain by blue-gray cherty quartzites, which form a distinct anticlinal fold. In the limestone, not far above its junction with the quartzites, characteristic specimens of *Loftusia* were discovered.

Marble Mountains.

General character of the range.

This high and broken range extends from the Junction Valley, in a north-north-west direction, for about twenty-five miles, its extremity lying just beyond the edge of the map. In its southern part, it has an average breadth of seven miles, but toward the north, it decreases in importance and eventually ends in a pretty acute point, the basaltic rocks of the plateau apparently running completely round it. These mountains are almost entirely devoid of surface covering, whether drift material or vegetation, and their general character as limestone masses may thus be clearly seen even from a long distance. In its composition the range precisely resembles the Pavilion Mountains, of which it is in fact the continuation. Its western side is bounded, as already explained, by a long and straight valley. The eastern side faces the great basaltic Green Timber plateau. Both sides were seen along their entire length, and everywhere the mountains appeared to consist wholly of limestone, though, undoubtedly, a closer examination would lead to the discovery of minor intercalations of other rocks. The limestones of the southern part of the range, along its eastern face, appear to dip westward at low angles. At the extreme head of Clinton Creek, in the centre of this part of the range, some yellowish and black cherty quartzites were found, dipping S. 65° W. $<$ 60°, but the surrounding mountains still appeared to be composed almost entirely of limestone. To the west of Big Bar Lake, the mountains were again found to be composed of gray fine-grained limestone, and at the extreme northern end of the range a similar limestone is the characteristic rock, with an observed dip of N. 50° E. $<$ 45°.

Almost entirely limestone.

Range a syncline.

There can be no doubt that this notable limestone range, like that crossed by Marble Cañon, forms a wide and well defined syncline, although the generally flexed character of the rocks in the vicinity, leads to the belief that numerous lesser folds may also occur.

One mile south of Sandy Creek, on the east flank of the range, a gray crystalline limestone was found interbedded with a silicified red argillite, the beds being vertical, with a north-and-south strike. These exposures attracted particular attention because of the

Traces of gold.

resemblance of the red rock to certain loose specimens found near Clinton, which had proved to be richly auriferous, as noted later. Specimens collected from this place showed traces of gold on assay.

Outlying Areas to the Southward.

Having now traversed the principal area of development of the Palæozoic rocks to the east of the Fraser, in as much detail as our present knowledge of them appears to render useful, two small outlying areas further to the south may receive a word of mention. Besides these, what remains to be said on the older rocks relates wholly to their representatives to the west of the Fraser, in the Coast Ranges or in their vicinity, and to rocks met with on or near the North Thompson River. The two localities above referred to are those at the head of the Botanie Valley and near the mouth of Iz-man Creek, respectively.

Head of Botanie Valley.

In the first-mentioned place, in the hills about a mile due north of Botanie Lake, a coarsely crystalline gray or white marble was found, associated with hard green hornblendic rocks and with some of a schistose character. The strike appears to be about north-west. These rocks are here much cut up by granitic dykes and intrusions, but seem to represent a much altered stage of the ordinary greenstones and limestones. Similar green rocks, but without the limestone, were again seen on La-loo-wissin Creek, to the northward, and appear to form a part of the same insulated area.

Iz-man Creek.

On the east side of the Fraser River, nine miles above Lytton and on both sides of the lower part of Iz-man Creek, a number of exposures of much altered rocks occur. These are in contact to the eastward with the massive diorites of Botanie Mountain, and the total thickness shown must at least be greater than 500 feet. The rocks consist chiefly of sheared greenstones, probably representing an eruptive, glossy felspathic schists very finely laminated and green felspathic schists.

Palæozoic Rocks of the Coast Ranges.

Composition of Coast Ranges.

To the west of the Fraser and south of Lillooet, a portion of the eastern part of the wide mountainous belt known as the Coast Ranges of British Columbia, is included in the present map. Exclusive of the Cretaceous strata near the Fraser, it has been found possible to separate the rocks met with in this rugged mountainous region into three classes, as follows :—1. Rocks which are evidently the representatives

in a more or less altered state of the Palæozoic formations already described. 2. Crystalline schists. 3. Granites.

The rocks of the first class are those which are here noticed, of those of the remaining two classes some description will be found in another place (p. 238 B).

In-koi-ko and Si-whe′ Creeks

Just opposite the area of rocks described near Iz-man Creek, and separated from it only by a narrow belt of the overlying Cretaceous, some much altered and corrugated beds are found near In-koi-ko Creek. These appear to have a width of about a mile, between the Cretaceous edge and the granite, though it was found to be a little difficult in this place to draw a line between the Cretaceous rocks and those of the older series. The latter consist of greenish and gray felspathic materials, sometimes with calcareous layers, and of quartzites, which are often nearly white and vitreous. The rocks are all much disturbed and are cut by numerous granite dykes before the main border of the granite is reached. This band of rocks continues northward, as shown on the map, gradually widening. Where it crosses Si-whe′ Creek, it is composed chiefly of gray schistose quartzites, generally somewhat micaceous and corrugated, and of green rocks, also more or less schistose, but evidently resulting from the dynamic metamorphism of some of the ordinary greenstones. Some distance further up this creek, a small area was found by Mr. McEvoy of greenish and dark gray hornblendic and micaceous schists, which appear to represent still further altered conditions of the rocks just noticed and closely resemble some of those of Iz-man Creek.

Askom Mountain.

In the vicinity of In-tl-pam Creek and Askom Mountain, the width of the belt of Palæozoic rocks becomes nearly three miles, and at a short distance to the north of the creek, these rocks come down to the edge of the Fraser, the Cretaceous being locally confined to the east bank. The rocks are here chiefly gray and black, hard, somewhat schistose argillites, with cherty quartzites of the same colours. With these are, however, included important intercalations of gray-green felspathic rocks, representing the ordinary greenstones in an indurated condition.

Serpentine and saxonite.

Two beds of serpentine (or two outcrops of a single bed) are also included in the section. One of these occurs a short distance north of In-tl-pam Creek, about half a mile from the river, the other about half way up the long ridge by which the summit of Askom Mountain was reached. The last-mentioned is distinctly schistose, and contains irregular harder layers, which, according to Mr. Ferrier, have the composition of saxonite.*

*Appendix I., No. 7.

Condition and attitude of the rocks.

Though somewhat irregular, the strike of all these rocks is generally north-north-westward, parallel to the main direction of the mountain ranges, with dips usually, but not invariably, to the westward. They are cut by numerous dykes, and are generally much shattered, with the development in them of considerable quantities of iron pyrites, the decomposition of which produces the general reddish colour by which Askom Mountain is characterized, in contrast with the usual gray colours of the granitic mountains of the region. On approaching the granite to the westward, the argillites become distinctly micaceous and glossy and are often corrugated, and together with the quartzites are everywhere cut through by numerous small quartz veins and seams. The broken and evidently crumpled character of the strata in this vicinity is such as to preclude any accurate knowledge of their order of succession or actual thickness, but the latter must be very considerable.

Evidently Câche Creek.

The composition and association of the rocks at this place, however, leaves no room for doubt that the greater part of them at least, represent that portion of the Câche Creek formation which is characterized by cherty quartzites and argillites, with some greenstones and serpentines, and of which the character, as displayed along the Bonaparte and Thompson valleys, has already been described. Their state of alteration and present appearance is, however, practically identical with that of the Boston Bar rocks, as met with in the Fraser Valley to the south of the area of the present map (see p. 101 B).

Texas Creek.

Still further north, on the lower part of Texas Creek, the Palæozoic rocks appear as a narrow band between the Cretaceous (here very much shattered) on the east and a massive granite on the west. At the bridge by which the stream is crossed, they consist of gray-green felspathic tuffs containing films of interbedded black argilite, but all excessively twisted and kneaded together. To the west of the granite just referred to, which is quite narrow, the Palæozoic rocks again appear, and were found by Mr. McEvoy to extend westward for a width of nearly four miles, when they are again bounded by granite. The rocks here consist principally of blackish argillites, generally somewhat micaceous, and often becoming black micaceous schists. Some gray, possibly felsphatic, schists are also found and numerous small quartz veins were noticed. The rocks are nearly vertical toward the east side of this belt, but further west were observed to have westerly dips in a couple of places. The belt of Palæozoic rocks here crossed by Texas Creek, is evidently the same with that found further north on Cayoosh Creek, and there examined, and the auriferous character of the rocks on Cayoosh Creek renders their extension here important.

Relation to Cayoosh Creek exposures.

G. M. Dawson.—Photo. July 26, 1890.

VIEW IN THE COAST RANGES.
Looking Southward from Askom Mountain.

In following the west side of the Fraser Valley from Texas Creek to Lillooet, much-shattered, gray, cherty quartazites, associated with a bed of serpentine, are found three miles north of Texas Creek. The strike of these rocks precisely accords with the direction of the valley, and they continue to appear along it at intervals for five miles, or to Cayoosh Creek. Hard greenstones also form a part of the series. The serpentines are particularly well shown near the road, about a mile south of Cayoosh Creek. The same bed of serpentine was again found a mile and a half beyond Cayoosh Creek on Hoey Creek, behind the town of Lillooet, and rocks of the character of those just noticed evidently run on in the eastern part of Mount McLean, still further north. Texas Creek to Lillooet.

Cayoosh Creek, which in late years has been the scene of somewhat important placer-mining and near which veins of auriferous quartz have been found, was examined for about five miles westward from the bridge, or to the Bonanza mine. It cuts across the strike of the rocks nearly at right angles. Near the bridge and mill, the stratified rocks consist, so far as seen, of blackish and greenish quartzose schists, but they are much broken up and confused by large dykes of gray granite, which lie nearly in line with the granitic mass of Mount Brew, to the southward. Section on Cayoosh Creek.

The stratified rocks appear, as seen in the end of this range nearest to the Fraser, to have a general easterly dip at low angles. They may thus be supposed to pass beneath the horizon of the serpentine and associated rocks, the strike of which along the west side of the Fraser River has already been traced. Further up the stream, opposite the first large valley from the south, the beds assume nearly vertical attitudes, but still further in the same direction, they again flatten out, and near the Bonanza mine are found to have easterly dips at moderate angles. It is not known whether the zone of nearly vertical rocks represents a compressed anticlinal or synclinal form, or whether it merely consists of a number of compressed smaller folds; but that the rocks are everywhere much plicated on a small scale, is evident from the conditions in limited sections and even in hand specimens.

The greater part of the rocks met with in the cross-section afforded by Cayoosh Creek, may be described as black or blackish argillites, often lustrous, sometimes much wrinkled and corrugated, and occasionally micaceous with very fine mica. Many of them are more or less distinctly calcareous. Near the Bonanza mine, a rather notable development of black and probably slightly graphitic argillites occurs. Inter- Character of rocks. At Bonanza mine.

bedded with these are some gray felspathic schists, which occasionally show the drawn-out forms of their original constituent particles, and have evidently, like the similar rocks of the northern part of Glen Hart (p. 87 B), and some of the Boston Bar rocks been produced by the action of pressure upon volcanic ash rocks or volcanic tuffs. Some green schists, chloritic and epidotic, are also found, as well as green rocks of the same kind not notably schistose, and still preserving the character of ordinary altered tuffs. Some of these are finely plicated and exactly like those seen at the bridge on Texas Creek (p. 98 B). In one place, not far from the east end of Seton Lake, a gray saussurite rock was collected, and at two miles and a half below the Bonanza mine, a zone several yards in thickness of greenish-gray talc-schist was observed to be interbedded with the series.*

Saussurite.

The auriferous quartz veins which intersect these rocks are described on a later page with other occurrences of economic minerals.

Seton Lake.

For about a mile, along the lower part of Seton Lake, on the north side, rocks generally similar to those of Cayoosh Creek are found, including indurated glossy argillites and green schists, with some cherty quartzites more or less foliated, and a little greenish schistose serpentine. With these are rocks of gneissic appearance, some of which are probably foliated granite, as at a short distance further west along the lake a mass of scarcely foliated gray granite is met with.

Outlines given to formations in Coast Ranges.

Respecting the outlines given to the Palæozoic rocks and the granites in the part of the Coast Ranges included by the map, it may be explained that these are based upon a certain number of traverses, shown upon the map, in conjunction with sketches and bearings obtained from several of the higher points. They can thus be assumed to possess but a general accuracy. The western edge of the main mass of granitic rocks was nowhere actually reached, but beyond it, the mountains are evidently composed of schistose rocks, and the line is approximately drawn so as to separate the two classes of mountains. It might almost be assumed that the schistose rocks on the west are of the same character with those above described, but additional certainty is given to this assumption by the fact that these rocks come out in force on the Fraser River, in the line of their strike, in the vicinity of the mouth of Salmon River, some distance beyond the south line of this map. These rocks have been examined, and it is found that they run along the part of the Fraser River referred to, as far as North Bend and a little beyond, while on the opposite side of the river

Rocks to west of main granite axis.

*See Appendix I., Nos. 16, 17, 18, 20.

they constitute the series which in the original report of 1871-72 was designated the Anderson River and Boston Bar series. The lithological characters and present appearance of these rocks are identical with those of most of the Palæozoic rocks here described, and there can be no reasonable doubt that their age is the same. The actual width of the belt of Palæozoic rocks in the south-western angle of the present map remains, however, indeterminate.

In order to afford a more definite idea of the Palæozoic rocks which enter into the composition of this part of the Coast Ranges, it will be advisable to add some notes on the Anderson River and Boston Bar series, above referred to, in its typical development along the Fraser River to the south of the present map. Some notice will be found of these rock in the reports for 1871–72 and 1877–78.* In the last-mentioned report, for the sake of brevity, the beds in question were generally designated merely as the Boston Bar rocks. In 1888 they were examined along the line of railway on the west side of the Fraser, where it was possible to obtain a better idea of the series as a whole than had previously been gained on the old wagon-road on the opposite side. Boston Bar rocks to south of map sheet.

Speaking generally, these rocks occupy the west side of the valley from a point about three miles below the cantilever bridge to one three miles below North Bend station, a distance in all of about nineteen miles. They are separated by a mass of granite from the Cretaceous rocks seen near the cantilever bridge, this granite being the continuation of the main granitic area shown on the present map to the west of the Fraser. The strike of the rocks crosses the Fraser valley at a very oblique angle, the belt of schistose or slaty rocks being continued to the northward, after leaving the Fraser, in the Salmon River valley, and to the southward, east of the Fraser, along the Anderson River valley. The obliquity of the line of examination does not favour the definition of an exact section, and the observations do not admit any precise thickness to be given for each of the various classes of rocks, but their order and character is approximately as follows :— Cantilever bridge to North Bend.

The first, and presumably the lowest rocks, seen just south of Quoieek River, are dark gray, quartzose mica-schists. About four miles further south and probably considerably higher in the series, somewhat similar, but pale gray, highly quartzose schists were next seen. These are followed by greenish, rather lustrous schists, and thin- Order of superposition.

* Reports of Progress, Geol. Surv. Can., 1871-72, p. 62.; 1877-78, p. 73B.

bedded cherty quartzites with slightly micaceous, shining, black divisional planes, and by massive gray indurated sandstones, verging on quartzite, but not cherty. Overlying these beds, are dark glossy schists and quartzites. Then, after a considerable concealed interval, dark argillite-schists and schistose quartzite, the former somewhat graphitic. These rocks are seen in cuttings from a mile to two miles south of Keefer Station.

At the south end of the Salmon River bridge, graphitic argillite-schists, with talcose and quartzose schists with a bed of nearly massive gray talc, occur, the whole followed by more blackish argillite-schists.

Thickness.

Near the 134-mile post on the railway, the section is interrupted by the appearance of gray gneissic rocks, which may be regarded as probably representing a mass of foliated granite.

If, as is supposed, the above represents an ascending series, terminated above (and to the westward) by the gneissoid rocks, the thickness displayed must be between 6000 and 7000 feet, of which the greater part is made up of argillites in different stages of alteration.

Rocks near North Bend.

Beyond the gneissoid rocks, after a concealed interval, black argillites are again found in large exposures between one and two miles above North Bend station. These are very regularly bedded and banded with thin gray layers, and with them are some gray quartzite-like sandstones. Two miles to the south of North Bend, black, shining argillite-schists, becoming chiastolitic in places and interbedded with dark gray mica-schist, are exposed. In following these rocks for a short distance in the cuttings, the micaceous schists are found to become more abundant and coarser grained, resembling gneisses, while many fine-grained granitic dykes cut through the rocks, and in some instances were seen to hold included fragments of the gray schists. A little further on the usual massive gray granite reappears.

Junction with granites.

This junction of the Boston Bar rocks with the granites, which may be observed in detail, might be assumed to show a blending and true interbedding of the argillites with gneissic rocks; but it is believed that the appearance presented is the result of ancient granitic intrusions among these rocks near the line of contact, and that the whole composite mass of granitic and stratified rocks has subsequently been subjected to great compression, such as to induce a foliated structure in the granitic material.

East side of Fraser.

In addition to the rocks above mentioned, thin beds of gray laminated limestone, green schists, and gray felspathic schists formed from squeezed volcanic ash, were observed in certain places on the east side

of the Fraser in 1877.* The gray schists are identical in character with those noticed in the northern part of Glen Hart (p. 87 B).

Palæozoic Rocks on and near the North Thompson River.

These are believed to be separable into two great groups, of which the higher is wholly or in great part Carboniferous, and referable to the Câche Creek formation, the lower to the Nisconlith and Adams Lake series, correlated in a general manner with the Cambrian; as elsewhere explained (p. 27 B). The nature of the provisional line of division which has been drawn on the map between the Câche Creek and Nicola formations is also referred to on another page (p. 124 B). Rocks of Cambrian and Carboniferous age.

In noticing the Palæozoic rocks of this vicinity, it will be convenient to begin with those assigned to the Câche Creek formation, in order that these may be more closely compared with the rocks of the same formation, to the description of which the immediately foregoing portion of this report has been given.

Rocks referred to the Câche Creek Formation.—An attempt has been made, along the lower part of the North Thompson, to obtain the necessary data for the construction of a section of the rocks there found and characteristic of the adjacent country on both sides of that river. The sides of the river-valley appeared to be the only place in which sufficient connected exposures of these rocks occurred to offer any prospect of such a section, although it was known that the general direction of strike is oblique to the valley, being in fact about north-north-west. The information obtained along both sides of the valley has since been combined, but with very indifferent results, in so far as the main purpose of the examination is concerned. Both strikes and dips proved to be exceedingly irregular in detail, and the rocks of the region generally are so much shattered and disturbed, that it is practically impossible to trace out single beds for any considerable distance. The diagramatic section (No. 3), which has been drawn as an attempt to represent the structure along a part of the valley, extends from the north side of Reservation Creek, northward, to the vicinity of the granite mass which comes out on the river beyond Sullivan Creek. Section along lower North Thompson Section No. 3.

The general character of the rocks met with may be briefly described as follows:—Blackish or dark gray argillites preponderate in the section. These are usually shaly, flaggy or slaty, but are so much cut General character of rocks.

* *Op. cit.*, p. 73 B.

up by jointage-planes in every direction, that they generally crumble away readily into rubbly slopes, like those seen descending from the higher parts of Paul's Peak. The argillites are very often more or less calcareous, sometimes slightly micaceous near their contact with the granitic masses, and particularly so in the vicinity of the granite near Jamieson Creek. They are frequently somewhat silicified, and then become black or grayish, fine-grained rocks like chert or hornstone, resembling the cherty quartzites of the Câche Creek formation on the Bonaparte River and elsewhere to the westward. With the argillites, hard grauwacke sandstones are in many places found to be interbedded. These are generally of paler colours than the adjacent argillites, and pass, in several places, into beds of fine-grained conglomerate or breccia, of which the constituents are rather varied, but which often hold black and gray slaty or schistose fragments, which may have been derived from Cambrian strata, like those seen in the section above Fish-trap Rapid (p. 107 B). The conglomerates have in some places become highly silicified, and have been so much squeezed that their pebbles are flattened out parallel to a common plane.

Limestone beds.

In addition to these rocks, the section comprises at least two beds of limestone, and considerable bodies of greenstone of contemporaneous origin and not infrequently of the character of a diabase-agglomerate. The higher of the two beds of limestone, appears to have a thickness of 100 to 200 feet, while the lower is much thicker. The lower limestone is immediately overlain by a bed of conglomerate of the kind already described, the association being apparently rather constant, as it was observed in several localities. This limestone is the lowest rock clearly recognized in the section, and the upper limestone is probably about 2000 feet above it, the intervening rocks being for the most part argillites, &c., as already described. Above the upper limestone, diabase and similar volcanic intercalations are more abundant, constituting a great part of this portion of the series.

Thickness.

The whole thickness of beds seen on this part of the North Thompson appears to be about 7500 feet.

The tracing out in detail of the limestone beds contained in this series of rocks, appears to offer the only method of obtaining more exact knowledge of their stratigraphy and thickness, and the age assigned to the whole series depends chiefly upon that indicated by the fossils contained in the associated limestones, a reference which appears to be justified by the interrelation of the various component members of the series, as well as by their resemblance to the rocks already described to the eastward.

The best exposure of the limestone bed, above designated as the lower limestone, is found on the west bank of the North Thompson near Venn's, almost directly opposite the mouth of Sullivan Creek. The dip of the limestone is generally eastward, but just at this place the direction of its strike appears to change. It has been followed in a north-north-west direction along the higher slopes of the valley for about three miles. To the southward, it turns more to the west, and possibly abuts against the granite mass found near Jamieson Creek. The outcrop near Venn's is probably the best and most accessible source of lime for burning to be found along this part of the river. Outcrops of limestone.

On the opposite side of the river, a mile north of Sullivan Creek, and almost in contact with the edge of the granite there, exposures of the upper limestone are seen. These run northward parallel with the main direction of the last-described band, crossing the river, and are again seen on the west side of the river two miles and a half further northward. In both cases the dips are to the eastward.

Another outcrop, believed to be of the upper limestone, is found a mile and three-quarters south of Edwards Creek, on the east side of the river; and between three and four and a half miles further south, on the same side of the river, several exposures referred to the same upper limestone band occur.

Still another prominent outcrop of limestone appears to the east of the North Thompson valley, in the Inner Valley, five miles due south from the upper part of Edwards Creek. This may probably be the lower band, and is again undoubtedly the same with the limestone seen in extensive exposures in hills to the north of the South Thompson, about ten miles east of Kamloops, a short distance beyond the east edge of the present map. The limestone of the Inner Valley is almost entirely composed of crinoidal fragments, and large round crinoidal columns more than an inch in diameter occur in it, but nothing more characteristic in regard to its age was observed. In the case of the limestone on the South Thompson with which it is correlated, the evidence of Carboniferous age is decisive. The abundant occurrence of *Fusulinæ* in it is noted in the report for 1877–78, (p. 80 B) where it is stated that the mass of the rock is made up of crinoidal debris and fragments of small corals. Imperfect remains of brachiopods were also found, including a *Rhynchonella* and a shell which may be *Hemipronites crenistria*. Since that time some beds have been found to be almost composed of large pear-shaped foraminifera referable to *Saccammina Carteri*, Brady, a form which in Scotland occurs both in the Fossiliferous limestone.

Lower and Upper Carboniferous limestones. A *Valvulina* was also observed, closely resembling *V. palæotrochus*, Ehrenberg.

Rocks of Paul's Peak.

The greater part of Paul's Peak, and of the high ridge running eastward from it to the edge of the map, consists of hard, splintery and sometimes cherty, dark argillites, with grauwacke-like quartzites and occasional greenstone or felsite beds.* These rocks represent the continuation of those described in the southern part of the section along the North Thompson, in the strike of which they lie.

Similar rocks again occur in the opposite hills, to the east of Kamloops, on the south side of the South Thompson.

Rocks of Garde Lafferty.

The eastern part of the tract of country named the Garde Lafferty, approximately from a line drawn through the long lake with lines in its centre, is again occupied chiefly by rocks resembling those of the lower part of the section on the North Thompson. They consist, like these, of argillites, grauwackes, and some beds of fragmental diabase rocks. The characteristic black cherty beds are also well represented. These rocks scarcely show any development of mica on their bedding planes, but they are often much shattered, disturbed and jointed in all directions.

Dolomitic veins.

In following the hills which face toward Kamloops, on the south side of this tract, these rocks are in one place, for a width of nearly a mile, not only excessively shattered, but also highly charged with silica, dolomite and iron pyrites, and traversed by veins of more or less siliceous dolomite. The red and yellow colours of the hill-sides due to the disintegration of this band of rocks are visible from afar. The change has evidently been produced by solfataric action proceeding along a system of fractures, which here runs in a north-westerly direction. The same solutions, issuing through these older rocks, have doubtless caused the dolomitization observed in some of the lower parts of the Tertiary in this vicinity (see p. 163 B).

Doubt attaching to North Thompson section.

Reverting to the section along the North Thompson, first described under the present heading, it is proper to explain that much doubt still attaches to it. The existence of considerable faulting parallel or nearly parallel to the line of the valley is suspected, and it is probable that a line of this kind separates the Câche Creek rocks from those of the Cambrian in the vicinity of Fish-trap Rapid. Some facts noted in the course of a detailed examination along the valley south of Sullivan Creek, led to the belief that two distinct series of rocks may co-exist there, in which cases it is possible that beds of the Nicola

*Appendix I., No. 19.

formation may be represented as well as those referable to the Câche Creek. This appearance may, however, be due merely to two superposed systems of folding, and meanwhile, the evidence as it stands, favours the inclusion of the whole of the beds in the Câche Creek formation.

Rocks near Watching Creek.

About the head of Watching Creek, and on the thickly wooded plateau for some miles to the east of its valley, rocks evidently representing those of the lower part of the North Thompson, were again observed. The principal direction of strike is here about north-east by south-west, while the varying dips indicate that these rocks form a series of folds. The materials are principally argillites, not notably altered, though indurated, and seldom at all schistose in character. They are often very finely bedded, and not infrequently more or less calcareous. With these are interbedded some grauwacke sandstones and conglomerates, as well as beds of altered volcanic material, some of which are evidently fragmental in character. These are seldom notably green in colour, and one of them, microscopically examined, appears to be a diabase-porphyrite.* Bands of blackish limestone were also noted in some places, interbedded with the argillites.

Cambrian Rocks near Fish-trap Rapid.

Section No. 2, Fish-trap Rapid.

Between the mouths of Whitewood Creek and Louis Creek the North Thompson assumes a north-east and south-west trend, cutting across the strike of the rocks nearly at right angles, and affording the most satisfactory section of the Cambrian rocks met with in the area of the Kamloops sheet. Much of this part of the valley is narrow, and the rocks are fairly well exposed in it. The section as presented (No. 2) runs from the vicinity of Fish-trap Rapid to the lower part of Louis Creek, about six miles, and thence northerly to the vicinity of the Barrière River, about three miles further. The observations upon which it is based were made, for the first part of this distance, along the south-east side of the North Thompson and along the valley of Louis Creek for some miles above its mouth. For the second part, chiefly in the hills to the east of the North Thompson a couple of miles back from the river.

Central anticline.

The oldest rocks found appear in the form of a somewhat contorted anticline, of which the axis seems to slope down to the north-westward. These are referable to the Nisconlith series and consist of hard black argillites and argillite-schists, often rather lustrous from

*Appendix I., No. 6.

the development of minute mica crystals, and passing from these in some places into well characterized black micaceous schists. These black schists do not appear to be calcareous. The thickness represented is about 3100 feet, but the base of the series is not seen. The highest beds appear to blend with the rocks of the next overlying series, which consists chiefly of greenish and gray schistose rocks resulting from the dynamic metamorphism of diabases and diabase agglomerates and representing the Adams Lake series, or a part of it, with an estimated thickness of 9500 feet.

Rocks to south-west.

In the syncline at the south-west end of the section, about 6000 feet of the lower part of these rocks is seen. They are here less altered than those on the opposite side of the main anticline, and are clearly recognizable as ordinary green altered diabases, or greenstones, becoming more or less schistose in structure, but in some places still showing an original agglomeritic character. The prevalent colours throughout are greens and gray-greens.

Rocks to north-east.

On the north-east side of the anticline of Nisconlith rocks, the Adams Lake series recurs in the manner shown in the section. Its rocks here have suffered greater metamorphism and are chiefly represented by gray or greenish-gray often lustrous schists, with, in their upper part (and at a horizon higher than any represented in the first syncline) some rather considerable intercalations of blackish argillite-schists. The highest beds seen, in the centre of the north-eastern syncline, consist largely of quartzose schists, with quartzose and arkose conglomerates, more or less schistose, glossy gray or nearly white schists and some black argillite-schists. These have a thickness of about 2000 feet, in addition to that already stated for the lower part of the Adams Lake series.

North of Barrière River.

The exposures found on the lower part of the Barrière River, and along the east side of the North Thompson northward from that river, are insufficient to admit of the further continuation of this section, but it is believed that the greenish and bluish-gray altered diabases and felspathic rocks chiefly seen there, are also referable to the Adams Lake series, forming a still higher part of it and one which has escaped much of the dynamic change by which the beds above described have been affected. It is also probable, that the main strike of these beds here runs nearly parallel to the North Thompson valley, though the massive character of the rocks renders it very difficult to determine this.

Rocks assigned to the Cambrian, South of Fish-trap Rapid.

Cambrian south of Fish-trap Rapid.

The rocks in the hills to the east of the North Thompson, south of the Fish-trap Rapid section, have not been sufficiently examined to warrant any detailed description of them. It has been endeavoured to draw an approximate line between the Cambrian rocks and those referable to the Carboniferous, but this depends almost entirely on the lithological characters of the rocks, without any exact knowledge of the relations of the two series along their supposed line of contact. It is, however, very probable that this line is a faulted one, due to one or more faults which may nearly follow the general line of the North Thompson valley.

Near Sullivan and Edwards Creeks.

Between Sullivan and Edwards Creeks, and to the south of Edwards Creek, near the east border of the map, the rocks believed to be Cambrian consist largely of greenish, diabase-like materials in various stages of alteration, often schistose, and passing over into coarsely micaceous schists of almost gneissic aspect. These last are, however, almost in contact with one of the granite masses with which the structure of this region is complicated, and may owe their excessive alteration in part to that circumstance. With the above-mentioned rocks some hard, micaceous argillites occur, and white banded quartzite was also noted. A bed of highly crystalline limestone is also seen in a couple of places, where it appears nearly to coincide with the line between the argillites, referred to the Nisconlith, and the green schists, referred to the Adams Lake series, although no limestone was observed in a similar relation in the Fish-trap Rapid sections.

Between the south side of the Sullivan Creek granitic mass and Island Pond, near the edge of the sheet and beyond it, there is a considerable development of schistose argillites, much broken, but probably representing an irregular anticlinal elevation, which may be connected with the intrusion of the granitoid mass.

Rocks of the Plateau to the North of Whitewood Creek.

Plateau north of Whitewood Creek.

To the north of Whitewood Creek and west of the North Thompson, a belt of plateau country averaging about six miles in width, is occupied by rocks of which the stratigraphical position is very doubtful. It must be explained that this region of country is exceedingly rough and difficult to traverse, by reason of its wooded and broken surface, and that but a few exploratory lines have been carried through it.

Rocks assigned to Cambrian.

The trail which runs westward from the North Thompson to Bonaparte Lake, leaves the valley of the river about six miles above the mouth of the Barrière, and some three miles below the village on the Indian reservation. On this trail, near the foot of the steeply sloping side of the valley, and about 430 feet above the river, some brecciated gray limestone was first found, after which many fragments of dark argillites were observed, though not seen in place; but in the main, for a distance of about three miles, green, slightly schistose, altered diabases appear to be characteristic. These rocks are believed to form a continuation of those of similar character seen in the section near Fish-trap Rapid, and they are provisionally assigned to the Cambrian.

Rocks assigned to Câche Creek.

In following the trail westward from the point last indicated, a great series of dark-coloured and often nearly black schistose rocks is met with, which continues all the way to the edge of the granites on Eating Lake, or for a distance of eight miles and a half. The strike of these rocks, wherever observed, is not far from north-and-south, and the dips along the line mentioned appear to be uniformly westward, at low angles near the edges of the diabase series, but elsewhere probably averaging about 60°. The appearances thus indicate that these schists overlie the diabases, and if it be supposed that they form a continuous ascending series this would have a thickness of over 18,000 feet. It is, however, much more probable that folds or faults not recognized have to be allowed for, and that there is much repetition of beds, though their actual volume must in any case be very considerable.

Their character.

Lithologically, these beds consist of argillites, schistose or slaty, more or less distinctly micaceous and approaching in character to phyllites, and of fine-grained black or blackish rocks containing a larger proportion of bisilicate minerals, very much decomposed and altered and probably representing beds which have originally been volcanic in their origin. With these are occasional beds of hard fine-grained gray quartzite or grauwacke.

The appearance of these rocks alone does not enable it to be decided to what series they should be referred. They very closely resemble some of the strata common in the Cambrian, but they are equally comparable with the more highly altered beds of the Câche Creek formation, and are in some cases lithologically indistinguishable from strata described under the name of the Campbell Creek beds. The apparent absence of limestones constitutes a point of difference between them and the strata referred to the Câche Creek on the lower part of

the North Thompson, but this may depend merely upon the incomplete character of the examination made.

Southward, from Eating Lake to Poison Hill, following a little to the east of the main edge of the basaltic and granitic rocks, similar micaceous argillites and fine, black, micaceous schists are the predominant rocks, but the directions of strike and dip are less uniform. Near the head of Skull Creek, where that stream was crossed on the route indicated on the map, these rocks are singularly contorted, being affected, besides their main flexures, by close parallel folding in undulations from a few inches to a few feet in diameter. They are also here traversed by numerous small quartz veins, which show a tendency to follow the contorted bedding-planes and are characterized by parallel marks of shearing, which indicate compression acting in a direction of N. 40° E. or the reverse. Continuation southward.

The isolated area of old rocks shown to exist to the west of Skoatl Point, is so much covered by drift that its composition was very imperfectly ascertained. It appears, however, to consist chiefly of gray-green porphyritic diabase, much altered, and is provisionally referred to the Nicola series. Near Skoatl Point.

Two miles south-east of Poison Hill, the micaceous argillites were found to be interbedded with gray-green diabase-porphyrites,* in a manner precisely analogous to that observed on Campbell Creek (p. 123 B), and it is probable that the horizon is about the same in both cases. Quartz veins were noticed to be abundant here, but specimens of them subjected to assay proved to contain nothing of value. Near Poison Hill.

Similar micaceous argillites, with some diabase, apparently interbedded, were found to characterize the tract of country, some miles to the south-westward, in which the basalts have been cut through and in which Caribou Lake lies. The general direction of strike in all this region is north-west by south-east, and in the vicinity of Caribou Lake quartz veins were again noted to be abunbant. At Caribou Lake.

It will be understood, from the brief description thus given of a tract of country some seventeen miles in length with an average width of about six miles, that our knowledge of its geological structure is yet very imperfect. It is quite possible that the dark schistose rocks above described may eventually be found to belong to the Cambrian, and to represent an extension of the Nisconlith series. In that case a line of separation would require to be drawn between them and the rocks of Age uncertain.

*Appendix I., No. 5.

the lower North Thompson, and it is probable that such a line might be found to run from the vicinity of the mouth of Whitewood Creek to Basalt Point of the map.

Triassic Rocks, and Sections Illustrating the Nicola Formation.

Section South of the Ashcroft Cretaceous Area.

Examination of the section.

A notice of the rocks referred as a whole to the Triassic, under the name of the Nicola formation, may be begun by a short description of the section found along the east side of the Thompson, south of the Ashcroft Cretaceous area. This section was partially examined in 1877, and in 1888 some additional observations were made on it along the line of the railway, but the results obtained remained fragmentary. After all other parts of the area of the Kamloops map-sheet had been gone over, the unusual regularity of the rocks at this place seemed to render it desirable that they should again be examined, and two days were in consequence devoted to this in July, 1894. The section was found to be not so regular as had been anticipated, in consequence of the protrusion into it of several masses of the granitic rocks of the vicinity ; but the effect of these has been eliminated as far as possible, and there can be little doubt that the general order and composition of the series is now fairly well understood.

Fossiliferous beds.

The discovery of fossils at two different horizons has also added materially to the value of the section as a whole. Professor A. Hyatt has been so kind as to make a preliminary examination of these and a comparison of them with some of the collections lately obtained by him from Californian localities, the results of which are of great interest. He finds in effect that the fossils collected from the lower of the two horizons are undoubtedly Triassic, comprising a *Daonella* like *D. Lommeli*, a shell resembling *Panopea* (?) *Remondi*, Gabb, and a small ammonoid. Those of the upper horizon are probably Jurassic. This horizon is actually separated from the lower by about 12,300 feet of strata. The fossils found in it include *Lima parva*, Hyatt MS., *Entolium* like *E. equabilis*, Hyatt MS., *Pecten* like *P. acutiplicatus*, Gabb, and two species of *Rhynchonella*, one like *R. gnathophora*.

General lie of the strata.

The exposures which afford practically the whole of the measured section, occur on the east side of the Thompson Valley and in the adjacent hills in a distance of about four miles southward from the end of the Cretaceous area. The general dip is nearly north, or at right angles to the valley, the angles of inclination varying from about 15° to 50°. No evidence of important faulting was found, and it was possible to observe the angles of dip in many places, notwithstanding the generally massive character and originally volcanic origin of a large part of the

constituent rocks. The highest rock seen is a limestone, in small exposures in the hills about two miles south-east of the railway at Black Cañon. It is overlapped there by coarse basal conglomerates and breccias of the Cretaceous, consisting chiefly of granitic fragments with a calcareous cement. These exposures are somewhat removed from the main line of section, and are complicated by the occurrence of a small granitic boss, but there is little reason to doubt that the rocks seen in them are conformable with those included under No. 2, of the section. The lowest member of the section is that numbered 9. It occurs about two miles north of Spatsum station, where it is cut off by a projecting mass of granite, beyond which the regularity of the series becomes disturbed and the order of superposition doubtful. All the beds included in the section are believed to appertain to the Nicola series. The section obtained may be summarized as follows, in descending order :— Section south of Ashcroft.

	Feet.
(1.) Gray limestone, of which at least 20 feet was seen. It often contains numerous small angular fragments of siliceous rocks and is fœtid, when struck. Contains fossils believed to be Lower Jurassic..	20
(2.) Chiefly bluish and gray or greenish-gray fine-grained felsite or petrosilex, apparently passing into fine-grained decomposed diabases. Some agglomerate, composed of similar materials, is included in this part of the section, but nearly all the rocks break with a homogeneous sub-concoidal fracture	1,800
(3.) Chiefly purplish and gray rather fine-grained agglomerates, occasionally greenish and often with spots of epidote	1,300
(4.) This part of the section is represented by few exposures, but appears to consist chiefly of bluish and greenish-gray fine-grained felsites, occasionally somewhat porphyritic	2,090
(5.) Chiefly agglomerates, which are often fine-grained and pass into moderately well bedded grauwacke or arkose sandstones, generally indurated and often calcareous. Usual colour grayish. With these are associated (particularly toward the base) blackish argillite-like rocks and some thin beds of limestone and of fine felsite-like rocks	2,900
(6.) The upper half of this member of the section is composed of gray felsites with interbedded limestones, of which the thickest observed is about 20 feet. Lower half not exposed	1,550
(7.) Chiefly green diabase-agglomerates, often coarse	2,100
(8.) Chiefly green rather fine-grained diabase-agglomerates with interbedded blue-gray limestones. In one cliff showing about 500 feet of beds, one-third of the whole appeared to be limestone. The limestones are best developed in the upper part of this division and Triassic fossils were found about the middle	1,300
(9.) Chiefly gray and blackish fine-grained felsites	539
Total	13,590

It is very probable that another limestone bed of considerable thickness underlies the last-mentioned member of the section, but the strata become too much disturbed to enable this to be certainly determined.

General composition of the series.

In explanation of the above summary, it must be added that the subdivisions adopted in describing the section are somewhat arbitrary, there being no very marked distinctions of a natural kind between its several parts, which show on the contrary, throughout, much blending and interlocking. In a general way it may, however, be noted, that the lowest beds recognized are fine-grained, generally dark-coloured felspathic materials; that above these, and constituting the greater part of the lower half of the section, green diabase and diabase-conglomerates occur, and that with these most of the limestones are associated. That fine-grained, gray agglomerates or tuffs characterize the middle of the section; that the entire upper part of the section shows chiefly fine-grained diabases and felsites with some agglomerates, which are here often purplish. The last-mentioned part of the section contains little or no limestone until the highest bed (No. 1) is reached. The thickness of this bed was not definitely determined, but is probably not great.

The rocks included under division No. 2 of the section, were imperfectly seen in 1877, and were then supposed to form a part of the Cretaceous series, * an opinion which now appears to be definitely disproved. It will be noted that their lithological character is practically identical with that of the rocks now known to form the apparently highest part of the Nicola series near Nicola Lake (p. 136 B). The same rocks occupy a small tract to the east of the southern part of the Ashcroft Cretaceous area.

Rocks near Spatsum.

To the south of the section just described, after an interruption caused by a granitic intrusion, another isolated mass of rocks which is referred to the Nicola formation appears. This includes green diabase with some limestone, and extends as far as Spatsum station. Beyond this, the narrow selvage of rocks between the Thompson and the edge of the granite, is believed to be referable to the Câche Creek formation, with the exception of a patch occurring on the hill from which the Great Rock-slide descends. The upper part of this hill appears to be entirely composed of a peculiar breccia or agglomerate, much silicified, and holding numerous fragments of limestone. Some of the fragments of limestone and greenstone, or other felspathic rock, are nearly a yard in diameter. Where least altered this limestone is dark gray in colour, but it is often changed into a white marble, while other pieces show concentric zones of alteration on the outside, with a nucleus of little changed limestone. Crystals of iron pyrites are abundantly disseminated through the breccia while copper-staining is often notable in the crevices and joints. Great blocks of the brecci.

At Great Rock-slide.

*Report of Progress, Geol. Surv. Can., 1877-78, p. 112 B.

ated rocks, which in falling have bounded clear of the general slope, strew the terraces along the foot of the slide.

The great size of the constituent fragments of this breccia seem to show that it must have been formed at or very near to a centre of volcanic eruption, and this eruption, it is supposed must have occurred during the deposition of the Nicola formation, to which the breccia itself is referred.

Great line of fracture.

It is believed that the Thompson, in this part of its length, coincides with the line of a fault, which is accompanied by much comminuted fracturing and crushing of the rocks in its vicinity. This faulting is probably in relation to the general run of the edge of the granite, and may possibly have occurred at the time of its intrusion. In any case, the rocks on the west side of the river are crushed, reddened, silicified and decomposed in a remarkable manner, elsewhere described (p. 80 B). No distinct connection can be traced between them and those on the east side of the river. They are referred as a whole to the Câche Creek formation, but may very possibly include broken remnants of parts of the Nicola formation as well.

Exposures near 89-mile stable.

In the hill above the old 89-mile stable, however, considerable exposures of limestone occur, in which fossils have been found, these Professor Hyatt refers to the same age as those of the highest bed of the section last described, or Lower Jurassic. These limestones further resemble that bed in character, and like it are charged with angular fragments of siliceous rocks. They are much broken up, and although associated with some greenish schistose rocks and with a gray spotted clastic felsitic or halleflinta rock, it is not certain that these are actually related to the limestone. The probable area of the newer rocks is indicated on the map. It may be added, that a couple of miles above the 89-mile stable, on the road, another limestone occurs in which Mr. Richardson collected a few fossils evidently referable to the Câche Creek formation, Mr. Billings having determined them as of an age between the "base of the Devonian and summit of the Permian."*

Fossils.

The fossils from the limestones near the 89-mile stable are described by Professor Hyatt as including a *Terebratula*, two species of *Entolium* and a *Pecten*, all closely resembling forms found by him in beds of Lower Jurassic age at Taylorville, California.

Section along the Thompson Valley from Bonaparte River to Copper Creek.

Section No. 1.

An examination along the line followed by this section appeared to be particularly important, as it constitutes the only direct link of con-

*Report of Progress, Geol. Surv. Can., 1871-72, pp. 61-62.

8½

nection between the older rocks of the western and eastern parts of the map-sheet. Elsewhere these two areas are separated by wide masses of granite or by Tertiary volcanic formations. A satisfactory connecting section along this line would have been all the more valuable because of the considerable lithological differences found between the Câche Creek and Nicola rocks of the two sides of the Kamloops sheet, but although examined with some care, and on several occasions, the section afforded has proved to be by no means a satisfactory one. The stratified rocks are broken up by large intrusive masses of a granitoid character, and, being for the most part old volcanic materials and much shattered, they do not supply the necessary data for working out the evidently somewhat complex structure. The section as presented (Sect. No. 1) must therefore be regarded as little more than a diagram, representing what is believed from the examinations made, to be the most probable arrangement of the older rocks. It affords a means of describing in outline the character of the rocks met with on both sides of the Thompson, and of bringing together the results of traverses made along the wagon-road and the railway line, as well as those of other traverses through the adjacent hills.

Line followed by the section.

The line of section approximately coincides with the east-and-west part of the Thompson Valley, running from its tributary the Bonaparte to Copper Creek, Kamloops Lake. It is to the wide and deep erosion of this great valley that the removal of the overlying Tertiary rocks is locally due. The actual length of the line of section upon which the observations have been projected, is about twenty-three miles, from end to end; but as drawn it is a couple of miles longer, because of the four distinct courses which it had been found best to follow in laying down the line upon the map. The line thus runs from a point on the Bonaparte River just south of the minute outlier of Tertiary rocks there, in a bearing N. 79° E., to a point on the wagon-road about a mile beyond the crossing of Eight-mile Creek. Thence, in a direction S. 70° E. to the Deadman River, near the bridge, approximately following the wagon-road. Thence in a bearing of N. 35° E. to the summit of the southern spur of the plateau, due north of Savona. Thence N. 68° E. to Copper Creek, which it reaches at a distance of about two miles from its mouth. The approximate contour of the surface is indicated by the upper line of the section, the horizontal and vertical scales of which are identical.

West end of section.

The section at its western end, where it leaves the Bonaparte River, shows the junction of the Câche Creek rocks with those of the Cretaceous. The line of junction can be clearly seen along this part of the

Bonaparte. The older rocks are at angles of 60° to vertical, and here consist of greenish or gray felspathic or diabase schists, with serpentine in considerable mass, and probably forming a bed in the series, as this rock is often found to do elsewhere in this part of the region. The Cretaceous rocks in contact with these, consist of greenish and bluish sandstones, which pass into coarse rough grits composed of heterogeneous fragments, and all much hardened. These also, so far as could be ascertained, stand at very high angles. It is probable that faulting accompanies the junction of the two formations, as represented on the section, but quite possible that the Cretaceous rocks here merely represent the western and overturned limit of a syncline.

Cretaceous rocks.

The Cretaceous rocks of the area crossed by the section are elsewhere described in greater detail (p. 154 B). The dips given to them in the section, embody the observations made in the vicinity but not all upon the line of the section, and it is impossible with the information gained to show the actual folds or faults by which this area of the Cretaceous may be affected. The general westward dip, at angles of 40° to 45°, of a great part of the series in this vicinity, is, however, very clearly seen in distant views of the north end of the wide ridge which occurs to the south-west of the lower few miles of the Bonaparte.

Basalt capping.

The hill crossed by the section in the middle of the Cretaceous area, is capped by nearly 200 feet of black columnar basalt, of which the individual columns were observed by Mr. McEvoy to have an annular concretionary structure.

Area of Nicola rocks.

A small wedge-like area of Nicola rocks, represented somewhat diagrametically upon the section as intervening between the eastern edge of the Cretaceous and the large intrusive mass next met with, indicates the position of an isolated area of these rocks which occupies several square miles on both sides of the river, south of the wagon-road and near the lower part of Barnes Creek. These rocks consist of greenish, grayish, blackish and often purplish fine-grained diabases and felsite-like materials, which particularly on the north side of the river, are often agglomerates. The gray and blackish felsite-like rocks frequently become porphyritic with small white felspar crystals. No limestone was seen, and very little of the ordinary coarse green diabase. The beds as a whole evidently represent part of the upper half of the Nicola series as shown in the general section to the south of the Ashcroft Cretaceous area (p. 113 B). So far as can be made out, they dip westward, passing beneath the Cretaceous at rather low angles of inclination.

Junction with granite

Their junction with the granitoid rocks to the eastward is hard to define, particularly to the south of the river, where detached areas of the

old volcanic materials appear to be included in the intrusive mass and to have been in process of incorporation with it by fusion. The character of the intrusive material is itself changed by this circumstance, but a couple of miles to the eastward it becomes an ordinary mica-diorite.

Reverting to the actual line of section, on the wagon-road, where the Cretaceous is directly followed by the intrusive mass, the latter shows similar evidence of having absorbed neighbouring parts of rock of the Nicola formation. It is not homogeneous, varying considerably both in colour and texture, although generally dark greenish or greenish-gray and usually fine grained. A microscopical examination shows it to be a porphyritic diabase, much resembling some forms of the rocks of Cherry and Battle Bluffs on Kamloops Lake.*

Tertiary volcanic rocks crossing section.

The area of Miocene volcanic rocks next met with, evidently occupies an old pre-Tertiary depression which here crosses the line of the Thompson River. The volcanic rocks have a width of about a mile in their narrowest part, at the river, and serve to unite the large regions characterized by similar rocks to the north and south of this portion of the Thompson Valley. Further to the westward, the same rocks form a bold escarpment along the north side of Semlin Valley and their western outcrop, to the south of the Thompson, is also very abrupt and rugged. On the east side, they are found to overlap a granitoid diorite at the mouth of Eight-mile Creek, at a height of about 250 feet above the river. The lowest volcanic rock here seen is a coarse basaltic breccia. Effusive basalt is elsewhere developed, as well as gray tuffaceous rocks, which in some places become almost porcelanous in character, reddish porous rocks, probably melaphyre, charged with zeolitic matter, and some pale augite-porphyrite. It is possible that sedimentary materials, such as ordinary sandstones or conglomerates, may occur in the bottom of the old depression here occupied by volcanic rocks, but none such were actually seen.

Character of eruptive

The area occupied by the eruptive mass next shown, to the east of the Tertiary belt, near Eight-mile Creek, has not been very accurately determined, particularly to the south of the river, where few exposures are seen. It consists chiefly of a green-gray mica-diorite. The next, and last, eruptive mass of importance, which breaks through the section about midway between Eight-mile Creek and the Deadman, may be mentioned at the same time. It is chiefly represented by dark gray-green, much decomposed, dioritic and gabbro-like rocks, some of which are not unlike those of the last. It resembles generally the granit-

*Appendix I., No. 84.

oid materials elsewhere found in the region, where near a contact with the stratified rocks, and on the east side of the mass, near the road, it includes a considerable quantity of diabase or similar material, derived from the stratified series. On the same side, in the hills to the north, however, considerable exposures of a bright red hornblende-granite were found. This is so different in character from the rest, that it probably represents another intrusion of different age, although its outlines were not separately traced out. It is too much shattered to be of any value for purposes of construction.

Nicola rocks, 8-mile Creek to Deadman.

While the stratified rocks seen between Eight-mile Creek and the Deadman River are almost entirely of volcanic origin, several broken outcrops of limestone have now been ascertained to exist in this part of the section. None of these can be traced far, and it is not certain whether there is one bed of limestone or two. Most of the associated volcanic rocks are very massive in character, and are, besides, even more than usually shattered and disturbed. It is thus almost impossible to ascertain the lie of the rocks from direct observation, but there are certain differences of texture and colour moderately constant along some zones, which, taken in connection with the limestone outcrops, afford a slight clue to the structure, and upon these the hypothetical attitudes given to the beds in the section are based.

Diabases and limestones.

It is unnecessary to describe the rocks themselves in detail. They consist in the main of different varieties of greenish, blackish and gray diabases, sometimes fine-grained and resembling felsites. Agglomerates are common and in these purplish tints are often observable, while in some cases included fragments of limestone are abundant. Some of the agglomerates also pass into fine tuffaceous materials. Purplish grauwacke-like beds of this kind constitute a somewhat notable feature. One of the freshest and most characteristic of them, collected one mile east of Penny station on the railway, has been subjected to microscopical examination with the result elsewhere detailed.* No distinctive fossils could be found in any of the limestones, although in the limestone outcrops near the road, about four miles west of the Deadman, organic fragments are common, and a peculiar structure of oolitic aspect was observed under the microscope. This particular outcrop was at first supposed to represent part of an unconformably underlying series of rocks. It is followed on both sides by purplish agglomerate full of limestone fragments. Its resemblance to the limestone on the Deadman, however, appears to show that it must be

*Appendix I., No. 35. Compare also Nos. 32 and 29, from the north side of Kamloops Lake.

regarded, like that limestone, as a part of the Nicola formation, and that it occurs here in the form of a sharp anticlinal, as represented on the section.

Apparent junction with Câche Creek rocks.

Another point of interest in this part of the section, is found on the wagon-road, nearly three miles east of Eight-mile Creek, where the road approaches a northerly bend of the river and is protected by dry stone walling both above and below. At this place, there is pretty distinct evidence of the unconformable superposition of rocks of the Nicola series upon a projecting boss of older rocks. The lower rocks consist of greenish to nearly white granular quartzite, extremely shattered and almost porcelanous at its junction with the overlying rock, which evidently represents an old lava-flow and is a hard, brittle, bluish-black, felspathic material.

The whole exposed mass of the lower formation is small, but an attempt was made to trace it upon the south side of the valley, where some shattered and whitened rocks of an originally volcanic nature were in effect found to occur. It is impossible to be certain of the relations of these to the surrounding Nicola rocks, but they have been indicated on the map, with doubt, as representing a part of the Câche Creek formation.

Remarkable dyke.

The rocks at the first-mentioned locality, on the road, are cut by a dyke of very peculiar composition and appearance, which is probably of Tertiary age. This is described by Dr. F. D. Adams in the appendix.*

Relation to section near Ashcroft.

Taken as a whole, there can I believe be little doubt, that the Nicola rocks seen along the Thompson between Eight-mile Creek and the Deadman, correspond with some of those of the lower half of the general section south of Ashcroft (p. 113 B).

Limestones and argillites, Deadman River.

Near the bridge by which the wagon-road crosses the Deadman River, on the east side of the river, are somewhat extensive exposures of limestone and argillite, with associated volcanic rocks which are believed again to represent those just referred to. The limestones are gray and fine-grained, while the associated argillites are often highly calcareous. The thickness of the limestones and argillites together appears to reach several hundred feet, but both the direction and amount of the dip is irregular, varying from N. 10° W. to N. 6° E. and from an angle of 20° to one of 45°. Both the limestones and argillites contain obscure fossils, among which portions of the guard of a Belemnite, with the remains of two species of Pelecypoda were recog-

* See Appendix I.

nized. The limestones are overlain by a pale felspathic rock, which weathers to a reddish colour, and which, though much shattered, seems undoubtedly to form a part of the same series with the limestones. The limestone here seen, is believed to be the same with one found some five miles up the Deadman, near the Indian village, which there dips eastward at an angle of 20°.

Rocks between Deadman and Copper Creek.

In order to ascertain what rocks follow the limestone in ascending order, a traverse was made from the bridge at the Deadman across the area of rough hills between that river and Copper Creek. The rocks met with on this traverse are represented in the eastern part of the section to which this description relates. Briefly characterized, these rocks consist chiefly of altered diabases, sometimes apparently compact, but often in the form of agglomerates, and generally greenish or greenish-gray in colour. At a height of about 1800 feet above the Deadman, a small patch of brown basalt occurs. The area of this is somewhat uncertain, but it undoubtedly forms a mere remnant of a more extensive flow, adhering to the surface.

Fossiliferous argillites.

Two miles and a half from the Deadman, on this line of traverse, a zone of hard highly calcareous argillites with some grauwacke-like sandstones was found. This is repeated at a further distance of about three-quarters of a mile, the interval being occupied by diabase agglomerates containing some calcareous fragments. The dips of both outcrops of these argillites are very high, but there can be little doubt that they represent a somewhat compressed syncline. These beds contain a few fossils, among which Prof. A. Hyatt recognizes *Trigonodus*, a *Cardita* and a *Daonella* like *D. Lommeli* and apparently the same with one found in the general section south of Ashcroft, the assemblage being clearly of Triassic age.

Eastern end of section.

In this part of the section, the only dips actually determined are those of the limestone at Deadman River and those of the argillites near the summit of the hills. The intervening indications of dip are therefore conjectural, but the return of the limestone on the east side of the syncline appears to be indicated by the facts detailed in connection with the section along Kamloops Lake (Sect. No. 5), which in part runs parallel to this one. The conglomerates at the base of the Tertiary, represented at the east end of this section, are the Coldwater conglomerates described in the Kamloops Lake section just referred to. They appear to be immediately followed by an overflow of igneous rock rich in olivine, probably a picrite-porphyrite, which seems to be the lowest of the Tertiary igneous materials in this neighbourhood.

Thickness.

The information so far gained on the stratigraphical arrangement of the rocks referred to the Nicola formation in this section, is obviously too incomplete to afford any definite idea of their sequence or thickness, although there would appear to be a volume of at least 5000 feet between the limestone of the Deadman and the fossiliferous argillites.

Section on Campbell Creek.

Campbell Creek section.

The older stratified rocks found to the south of Kamloops and the South Thompson River, are, for the most part, believed to represent the Nicola formation, but some considerable areas have been separated from these and referred to the Câche Creek formation. The grounds upon which this admittedly provisional separation is justified are elsewhere stated (p. 44 B). In describing the rocks of the region named, it will be most convenient to begin with the section afforded by Campbell Creek, in which strata of both these series appear to be represented.

Some account of a part of this section has been given in the report for 1877-78, but this included only the rocks seen near Shumway Lake, for which a thickness of about 500 feet was then ascertained.

Argillites and amphibolites.

It is unnecessary to repeat this description, but it must now be noted, in respect to it, that a considerable part of the beds there spoken of as altered argillites have since proved, on microscopic examination by Mr. Ferrier, to be very fine-grained amphibolites, which undoubtedly represent volcanic rocks of some kind, either tuffs or massive rocks dynamically altered. The alteration of the argillites proper is by no means great, and is chiefly confined to the immediate vicinity of the granitic intrusive masses.

Lengt the section.

The section has now been extended by an examination along the entire portion of the valley of Campbell Creek occupied by the stratified rocks, with a length of nearly two miles from the north end of Shumway Lake north-eastward to the edge of the granite in that direction, and of about four miles southward to where the stratified rocks are again cut off by granitic rocks, near Newman's house, at the mouth of Fish Creek. The first part of this section crosses the strike of the beds at a considerable angle, while the second part does so very obliquely. The general direction of the strike is about N. 15° W., while the dips are to the westward at high angles, varying from about 70° to 40°. Both strike and dip are notably regular or this region, and rock exposures are frequent.

Beginning with the lowest beds seen, at the north-eastern end of the section, the rocks represented may be described as follows, in ascending order :—

	Feet.
(4.) Fine-grained amphibolites and hard, splintery argillites, both well bedded and generally black or blackish, but occasionally becoming greenish-black	3,000
(3.) Massive, dark-greenish, rather coarse-grained diabase-porphyry (possibly intrusive)	600
(2.) Chiefly argillites, with fine-grained amphibolites and gray-green altered diabase (?) all well bedded.*	2,200
(1.) Chiefly green and gray altered diabase (sometimes agglomerate) with micaceous schists, often well bedded	2,500
Total	8,300

The rocks of Nos. 4 to 2 inclusive of this section are subsequently referred to as the Campbell Creek beds. Campbell Creek beds.

The argillites are often calcareous, but they blend so completely with the fine-grained amphibolites of similar colour and macroscopic texture, that it is frequently difficult to draw any line between the two classes of rocks. Some of the rocks are slightly lustrous on the bedding planes, from the development of small quantities of microscopic mica, but it is only toward the southern end of the section, between the upper end of Shumway Lake and Newman's that the alteration becomes considerable and the beds assume a schistose appearance. This alteration is clearly of a local character, and is as evidently connected with the granite in this vicinity. It affects the upper members of the section, which are preponderantly diabase-like in character, and has produced micaceous and diabase schists. The extreme term of this alteration is found at the edge of the granite, where the strike of the bedded rocks turns more to the westward, in conformity with the direction of this edge. On the hill ascended by the road going northward from Newman's, dark greenish diabases may be found changing into much paler grayish, almost gneissic, rocks, and all the different stages in this change may be noted.† Alteration of the rocks.

On the hills to the east of Newman's, about a mile from the road, and on both sides of Fish Creek, similar rocks of gneissic aspect occur as lenticular masses in the granite. No attempt has been made to indicate these on the map, where they are included with the granite, but they evidently represent detached masses of the stratified volcanic rocks. Gneissic aspect of some.

The upper part of this section, including about 2500 feet of beds, is that which is referred to the Nicola formation, while the Nature of the stratigraphical line.

*Appendix I., No. 8.

†Proterobase or epidioritie, according to Mr. Ferrier. Appendix I., No. 30.

lower members, or Campbell Creek beds, are assigned to the Câche Creek formation. No unconformity was, however, observed here, and apart from general considerations derived from a study of other parts of the district, there would be no local necessity for any important line of separation. The dividing line is here based almost entirely on the fact that above a certain horizon diabases and diabase-like rocks prevail, while below it, the rocks are chiefly fine-grained amphibolites or argillites, the latter appearing to be lithologically connected with the Câche Creek beds of the North Thompson, rather than with the great Triassic greenstone development of the Nicola formation. This line at least coincides with a marked change of conditions, and enables the separation on the map of a set of lower beds which in this region have peculiar characters and are pretty easily recognized wherever they occur.

Campbell Creek beds near Kamloops.

To the north-westward of the above-described section on Campbell Creek, and following the strike of its rocks, beds of identical character are found running on to the Thompson Valley. In the vicinity of Separation Lake and near the town of Kamloops, they consist chiefly of fine-grained blackish amphibolites and argillites, with grauwacke sandstones, containing in some cases fragments of hard black shales. These dip in various directions, and appear to be considerably disturbed and fractured, probably as a result of the proximity of the several granitic intrusions in this vicinity. They evidently represent, however, the lower part of the section seen on Campbell Creek, or that to which the name of Campbell Creek beds has been given.

Their junction with Nicola rocks.

The upper part of the Campbell Creek section is equally clearly represented by the greenish and gray diabases and diabase-conglomerates which lie below the Tertiary coal-bearing rocks near Guerin's, three miles south of Kamloops town, and form the ridge to the westward of the small stream which enters the Thompson at the old Hudson Bay house (at the west end of Kamloops), between that stream and the edge of the Tertiary.

As already stated, the line drawn between these two series of rocks is not entirely a satisfactory one, and it must, in fact, be regarded for the present as a provisional line only, for no unconformity nor any marked break has here been found. Had this particular tract in the vicinity of the town of Kamloops and Campbell Creek been alone examined, the two classes of rocks would undoubtedly have been considered as the upper and lower parts of a single series; but, being already in possession of the fact that the Carboniferous strata of the Câche Creek formation characterize the region to the north-eastward,

while those of the Nicola formation are characteristically developed to the south-westward, it becomes necessary to determine a line somewhere between them, and that above defined appears, in consideration of all the facts known, to be the most natural one.

To the north of the Thompson, the line of division is entered on the map in accordance with the same lithological basis, though, as already mentioned, it is very probable that the two formations are brought together in the region of the Garde Lafferty by faulting.

Stump Lake, Moore Creek and Upper Nicola.

Nicola rocks near Napier Lake.

To the south of the section on Campbell Creek, above described, after an interruption of some miles, occupied by the granitic and Tertiary rocks which surround Trapp Lake, the older rocks again reappear on the west side of Napier Lake and north of Fraser Creek. Where these rocks touch the shore of Napier Lake, they are not only close to the edge of the granite, but immediately underlie the massive volcanic rocks of the Tertiary, and have evidently been subjected to exceptional alteration by solfataric or similar action. They are much shattered, often highly silicified and pyritized and weather into rubbly red banks. Gray somewhat silvery schists, with some rather coarsely micaceous rocks of gneissic aspect, occur; but both these are associated with less altered porphyritic diabase in such a manner as to prove their origin from that rock Within the area of the granite, a couple of miles eastward, gneissic intercalations also occur, like those described above near Newman's (p. 123 B). To the north of Fraser Creek, and again not far from the south edge of the granite, dark green diabase is found, coarsely porphyritic, and with uralite crystals.

About northern end of Stump Lake.

Further to the south-west, about the actual head of Stump Lake, are much shattered and decomposed diabases, often highly dolomitized. The Tertiary volcanic rocks have evidently at one time extended over these, and the characters mentioned are often found in superficial parts of the older rocks in such a position. On the first small stream entering Stump Lake on the east, to the south of Fraser Creek, these rocks are followed by nearly black, very fine-grained amphibolites representing the Campbell Creek beds. These appear to be well stratified, and dip N. 60° E. $<$ 80. From this place, similar rocks have been traced south-eastward, nearly on their line of strike, for about five miles, beyond which the country becomes so thickly wooded and broken that it was scarcely practicable to follow them. They are represented on the map as running out in this vicinity, though it is possible that they may be continued somewhat further. They are generally nearly or quite verti-

cal, and the fine-grained black rocks are apparently in some beds true argillites, which occasionally show calcareous streaks and seem to be interbedded with green porphyritic diabases of the usual character, which to the south-eastward, became more altered.

Stratigraphical relations.

Thus far, from the vicinity of Napier Lake to the line of outcrop of the amphibolites and argillites, we evidently have represented the south-west side of a rather wide syncline repeating the rocks of the upper part of the section on Campbell Creek; but the thickness of the lower dark rocks here coming to the surface is very much less than that found in the Campbell Creek section, rendering it probable that they occur here either on the summit of a compressed anticline, or that they are cut off to the south-westward by a fault. The latter appears to be the more probable hypothesis, and a line of faulting running in a direction of about N. 20° W. would best accord with the observed facts. It may be added, that such a line if traced northward, is found to correspond with that of a fault noted as affecting at least the older portion of the Tertiary rocks on the south shore of Kamloops Lake, nearly opposite the mouth of the Tranquille River.

Development to the south.

To the south and east of the line of outcrop of the older rocks just referred to, the region including Stump Lake, Moore Creek, the Upper Nicola and the Douglas Plateau is occupied by rocks to which the key is afforded by the section on Campbell Creek. Much the greater part of this area is held by strata referred to the Nicola formation, including beds of that formation which must be stratigraphically much higher than those of any part of the Campbell Creek section. The remaining part of the area is occupied by the underlying dark amphibolites and argillites which have been provisionally attached to the Câche Creek formation. These are developed in greatest force about the Douglas Lake granitic mass, and there probably include beds lower than any seen on Campbell Creek. They also, however, probably occur in minor areas near the edges of the granite on Moore Creek.

Stratigraphy obscure.

This region is continuously bounded on the west by granite, and extends to the east and south as far as the borders of the map, the only notable exception to its general character, being found in the occurrence of the Douglas Lake granite mass just alluded to. The western portion of this tract of country, particularly about Stump Lake, has been pretty closely examined, but with results which, in so far as any complete understanding of the geological structure is concerned, must be admitted to be unsatisfactory. The massive character of many of the rocks, with their often shattered state, render the dips

and strikes very obscure in most places, and even when these are distinct, they are found to be irregular and conflicting. The general direction of strike is about north-west by south-east, but strikes nearly at right angles to this are not infrequent, while the beds, though generally dipping at high angles and sometimes vertical or nearly so, are occasionally almost flat.

General character of rocks.

That which is certain is that we have in this region a great development of altered diabases, generally of green colours, and among which porphyritic (uralitic) varieties are particularly characteristic. With these, and forming a lower part of the series, is a great thickness of fine-grained well stratified blackish and dark gray amphibolites, often simulating altered argillites and passing in places into distinct argillites of similar dark colour.

Probable wide

The lower rocks last referred to are found in their greatest development around the Douglas Lake granite mass, but are also seen along Moore Creek near the bordering granite on that side. It appears probable that a synclinal axis runs southward between these two places, in a sinuous course, beginning near the north-west part of Stump Lake, passing near Rockford, crossing the Upper Nicola, and appearing again plainly in the well marked syncline examined in the Meander Hills (see p. 136 B). It is certain, at least, that a wide belt of diabase rocks of the general character above noted runs south ward from the north end of Stump Lake to and beyond the border of the map.

Limestone beds.

On the west side of Stump Lake, a mile and a half from the shore and near the first small stream below the head of the lake, a bed of gray limestone was observed in association with the greenstones. It is not thick and is much broken, but contains some obscure organic remains, and resembles that met with on McDonald's River (Quilchenna Creek) to the south of Nicola Lake (p. 132 B). Although it cannot be traced out, and may even not be continuous, the occurrence of this limestone is interesting, as apparently fixing a horizon. Following the general run of the rocks, it is probable that the same limestone bed is that seen on the hills one mile east of the road and three miles south from Rockford. This strikes about north-and-south, and is nearly vertical. In thin sections this limestone has a greenish tint, which, under the microscope, is found to result from the inclusion of numerous small grains of a crystalline mineral. This has probably originally been pyroxene, but most of it is now changed to hornblende or to chlorite. The foreign constituent thus represented, has no doubt been introduced as a volcanic ash during the deposition of the lime-

stone, the circumstances being the same as those met with in the McDonald River limestone, described below.

It is believed that the two limestone outcrops referred to, represent points on the west side of the main syncline which has been suggested. No exposures of limestone on the opposite or east side were found, but, on the hypothesis advanced, the bed may be assumed to run along the hollow followed by the road to the east of Stump Lake, and to pass near to a point south-south-east of Rockford, three miles, where a diabase charged with small calcareous fragments was observed.

Rocks near Dropping-water Creek.

The following more detailed notes on the rocks of a few parts of this region may be useful :

To the west of Dropping-water Creek, and beyond the line of the Tertiary volcanic rocks in that direction, the older series is chiefly represented by dark green, gray-green and occasionally purplish, hard volcanic ash rocks or diabase-tuffs. With these are volcanic breccias of similar composition and some massive leek-green altered diabases of the usual kind. The fine-grained fragmental rocks are generally more or less calcareous, and are less indurated than most of the rocks in this region. Where the dip could be observed it is eastward at angles of 20° or 30°, and it is quite possible that these rocks may immediately overlie the horizon of the limestone above alluded to. They are identical in character with some of those found near Kamloops Lake and to the west of that lake in the vicinity of the Thompson River (pp. 119 B, 140 B).

Rocks of the character above described form a belt which runs nearly parallel to the edge of the Tertiary, and occupy much of the country between this edge and the upper part of Moore Creek. They are rather notably less altered than most of the rocks of similar composition found in the Stump Lake or Upper Nicola country ; and it is also to be remarked that, though they immediately underlie the Tertiary volcanic rocks, they have not been shattered or dolomitized like those occupying a similar position at the head of Stump Lake (p. 125 B).

To the west of Stump Lake, between that lake and Moore Creek, the rocks observed, in addition to the limestone already mentioned, were green diabases, generally porphyritic with some exposures of a gray arkose grauwacke or quartzite.

Valley of Moore Creek.

The valley of Moore Creek, running from north to south and ending at Nicola Lake, for fourteen miles nearly follows the junction of

the Nicola rocks with the granite. The occurrence of this line of erosion is evidently dependent upon the contact of the two classes of rocks, though the actual stream lies persistently at a small distance to the eastward of the edge of the granite, which is somewhat flexuous. The granite border was traced out here in some detail, because of its possible bearings on the metalliferous deposits of the vinicity of Stump Lake.

Character of contact with granite mass.

In going southward along the valley for the first ten miles, the rocks in contact with or near the granite border all appear originally to have been diabases or felspathic rocks of volcanic origin, like most of those in this field. These have suffered considerable local alteration in the vicinity of the granite and are thrown there into rather irregular attitudes, in respect to their dip and strike. The special alteration referred to is usually very apparent at a distance of a mile from the granite, but extremely altered forms are found only much nearer to it. Close to the granites, the rocks are gray, rather than green in colour, often gneissic in appearance, and frequently become more or less schistose with the development of considerable quantities of black mica on the planes of foliation. Some of these rocks which have been microscopically examined have the composition of amphibolites in which traces are occasionally still visible of the usual porphyritic character of the diabases from which they have been derived,* but few of the amphibolites here met with have the fine grained and regularly bedded appearance of those characteristic of the lower part of the section on Campbell Creek, previously described.

Campbell Creek beds.

Where the stratified rocks from a bay in the granite edge, about four miles north of Nicola Lake, the rocks above noted are, however, found to have in association with them some finely bedded hard argillite, of which the surfaces are very slightly micaceous. These are believed to be referable to the Campbell Creek beds of the Câche Creek formation.

Edge of the granite.

All these rocks are here traversed by numerous irregular and usually narrow quartz veins, but no granitic dykes were observed to cut them. The granite, near its junction with the stratified rocks is also somewhat modified, being in some places foliated parallel to the line of contact. In other places it becomes very fine grained and appears to consist entirely of felspar and quartz. It is also usually charged with pyrites grains, weathering red in consequence, and is often more or less silicified throughout its mass, besides being traversed by numerous small veins of quartz.

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* Appendix I., Nos. 11 and 12.

Rocks near Stump Lake mines.

The principal known metalliferous deposits of the vicinity of Stump Lake, are comprised within an area of about five miles in length with a maximum width of three miles, situated on the south-east side of the lake. Here a large number of veins containing silver ores, with some gold, have been discovered, and a considerable amount of work of a preliminary kind has been done on them. The greater number of these veins run in bearings between N. 15° W. and N. 15° E. Some notes concerning them have been given in the Summary Reports for 1888 and 1890, and a more complete account appears on a later page of the present report.

The country-rock of the region traversed by these veins, is almost uniformly a dark green or green-gray diabase-porphyry, in which large uralite crystals are often conspicuous. There are, however, occasional bands consisting of diabase tuff, well bedded, with others of a fine gray felspathic rock, also well bedded, and possibly a few layers of fine amphibolite. A diabase tuff of the kind referred to was found at the "Planet" mine, near the shore of Stump Lake. The felsite-like rocks were observed in the valley traversed by the road to the east of the lake. Near the metalliferous veins, the rocks are often much shattered and weather red from the presence of iron pyrites or dolomite with which they are frequently charged.

Rocks surrounding Douglas Lake granite.

Along the north-western side of the Douglas Lake granite, the country is deeply and nearly uniformly drift-covered, so much so that the boundary of the granite itself in this direction is somewhat uncertain, while very little is known of the rocks in its immediate vicinity, and the lines drawn upon the map must, in consequence, be considered as merely approximate. On the western and southern sides, however, the rocks are well shown in numerous places, and here the granite is found to be surrounded, for a width of about a mile and a half, with black and dark gray rocks of flaggy or schistose structure, consisting of argillites and fine grained amphibolites, with fine hard grauwacke sandstones, sometimes calcareous. These rocks evidently correspond with those of the lower part of the Campbell Creek section, but inasmuch as the distinction was not clearly made in the field between the fine amphibolites and the argillites, which they very closely resemble, it is not possible to state in what relative proportions the different classes of rock met with are present.

In one place, about half a mile east of the eastern extremity of the granite, rocks such as those above described were noticed to hold, apparently as interstratified masses, altered diabase-porphyry of greenish colour, the circumstances being the same with those noted in part

of the Campbell Creek section and also near the north end of Stump Lake, on its east side (pp. 123 B, 126 B).

The strikes of these rocks show a tendency to run in parallelism to the edge of the granite mass, and although there is some irregularity in this respect, as well as in that of the dip, the predominant dips are away from the granite at high angles. The impression conveyed is that the granite has been thrust upward, bearing the lower stratified beds, here seen, to the surface with it. No extreme alteration is observed along contacts with the granite in this case, though small quartz veins are rather abundant near it. Relations to granite, and thickness.

The thickness of these beds near the Douglas Lake granite, is roughly estimated as 7000 or 8000 feet, and they are overlain by green and gray diabases of the usual kind. The relations which these two rocks are believed to hold in this part of the region, are shown on the general section which is next described, but their actual junction was not seen and it is not known whether it is a conformable or an unconformable one.

General Section near Nicola Lake and Eastward.

In 1877 it was found that the south side of Nicola Lake, from the vicinity of McDonald's River (Quilchenna Creek) westward to the lower end of the lake, a distance of seven miles and a half transverse to the general strike of the rocks, afforded a fairly good section of the series which was then named the Nicola series. The further examination of the country made in later years has led to the discovery of few better general sections of these rocks. In 1889 an endeavour was therefore made to supplement the results of the paced survey carried out in 1877 along the southern border of the lake, by means of a traverse running along the crest of the ridge which bounds this part of Nicola Lake on the south side. The results obtained, taken in connection with the previous observations, somewhat modify the outlines of the provisional section given in the first report, and afford the data for the section now presented, which though still perhaps not entirely free from doubt in regard to its details, is believed to afford a fairly correct idea of the composition and sequence of the rocks exposed. It has further been endeavoured to extend the original section eastward through the Meander Hills to the Douglas Lake granite area and to combine the results of the whole in a single diagram. Examinations made of Nicola Lake section.

Though the greater part of this section (Section No. 4) lies a little beyond the southern border of the Kamloops sheet, no apology seems necessary in connecting its results with the report on that sheet, as it Section No. 4.

throws light on the general structure of the Triassic rocks of the region reported on.

Strike of rocks and trend of section.

The main direction of strike of the rocks met with along the lake-shore and in the ridge behind it, is about N. 10° W., and this is preserved with considerable regularity, though on following the beds across to the north shore, where they are found in contact with the southern end of the great granite mass, they are found to turn more to the westward. It is in fact probably in connection with the intrusion of this granite that the beds included in the section have become flexed as they are.

The section now given, is supposed to be drawn along the crest of the ridge and not along the lake-shore as was the case with that of 1877, the discovery of four new limestone outcrops among the rocks met with on the ridge, having afforded a clue to the arrangement of the beds which was formerly wanting. As now presented, the section includes three synclinal and two anticlinal axes, and in describing it, the outcrops of the upper of the limestones believed to be comprised in the series—that first seen to the east on McDonald's River,—are assumed to be those defining the widths of the several synclinal and anticlinal folds.

Limestones at McDonald's River.

Beginning at McDonald's River (Quilchenna Creek), at a point about a mile back from the shore of the lake, the first wide low syncline is found to have a width of about two miles and three-quarters, its western edge being more steeply inclined than its eastern. The eastern outcrop of the limestone and the rocks near it are thus described in the report for 1877. Some of the details then given were for the purpose of establishing the fact that the limestone actually forms an intercalation in the great volcanic series here represented, a fact which can no longer be regarded as in any doubt :—

"The limestone bed above alluded to is seen on the west side of McDonald's River, about half a mile south of the wagon-road, where it forms a prominent bare cliff about sixty feet in height. It has been burnt here, and found to produce good lime. At first sight this bed appears to pass below the volcanic rocks with a low westward dip, but on more careful investigation it is found that it is separated from the mass of these rocks by a fault which runs about S. 14° E., with the downthrow probably on the west side. The existence of this fault is so far unfortunate as it to some extent obscures the relation of the limestone with the volcanic series, which is a matter of importance. I believe, however, that the very great probability—almost amounting to certainty—of the limestone belonging to the volcanic series can be shown in several ways.

"The limestone is very much broken and disturbed, but on the whole appears to dip westward at an angle of about 20°. The volcanic rocks on the west side of the fault seem, in so far as their attitude can be ascertained, to lie in a similar position. In its normal form the limestone is gray, granular, but not very highly crystalline, evidently composed of organic fragments, among which joints of crinoidal stems are most abundant. A few obscure larger fossils are also occasionally present, including a *Terebratula*. In some places, however, it becomes filled with green granules, which project on weathering, and by examining various parts of the exposure these can be found at times to be much more abundant, so much so as to form a coherent mass after the whole of the calcite has been removed. In other layers the limestone is almost altogether replaced by this material, which is pale green in colour, and holds only scattered calcareous particles, among which crinoidal joints can at times be made out. On removing the limestone by an acid, the residuum appears to be felspathic, and fuses pretty readily on the edges before the blowpipe.* It resembles the finer constituents of some of the volcanic agglomerates to the westward, and has, without doubt, been a volcanic ash or sand, mingled in varying proportions with the limestone toward the close of its deposit. * * * On the opposite side of the fault the first rock seen is an amygdaloid, which, though its cavities are in places charged with a siliceous mineral, is generally highly calcareous, and in some layers appears to be more than half composed of calcite. Though, owing to the fault, the precise relation of this rock to the limestone can not be made out, it would appear that calcareous matter was still very abundant at the time the amygdaloidal material was poured out over the bottom."

Admixture with volcanic materials.

The amygdaloid last noticed may thus be supposed either to immediately overlie the limestone or to occur stratigraphically at a very short distance above it. The mass of this amygdaloid is a purplish and greenish altered diabase, and it has evidently in some places been originally an almost frothy scoriaceous volcanic rock. It is followed to the westward, in ascending order, by a great series of massive or brecciated diabase-porphyrites.† For several hundred feet above the limestone these are characterized by the frequent occurrence of purple colours, though green colours are also present. The higher beds become almost entirely green or greenish-gray, but do not otherwise materially differ from the lower. The thickness of these beds, above the limestone, appears to be about 2600 feet.

Overlying amygdaloid.

* On microscopical examination the green granules in the limestone are found to consist largely of hornblende, which is probably an alteration product of pyroxene, associated with some felspar and a little quartz.

† Appendix I., Nos. 23, 33.

Limestone west of first syncline.

Where the limestone recurs on the west side of this syncline, it is again found to be overlain by a considerable thickness of notably purplish, porphyritic rocks, but these are here slightly schistose in character, doubtless as a consequence of the greater pressure to which they have been subjected. The limestone itself is again about sixty feet in thickness, and its connection with the volcanic rocks next underlying it is clearly shown. At its base it becomes interbedded with green felspathic schists, which still afford evidence of their original fragmental character and undoubtedly represent altered ash rocks or tuffs.

Rocks of first syncline.

In the centre of this first syncline and overlying the generally porphyritic diabases previously described, are certain bluish or greenish-gray fine-grained rocks, which belong to the highest part of the entire series represented in this section. Their thickness, as they are found in this syncline, appears to be small, but they recur in much greater volume in the westernmost syncline of the section, in which they continue as far as the lower end of Nicola Lake. No means was found of obtaining an approximately correct estimate of their thickness, but this must be at least several hundred feet. In some places they are very distinctly bedded and they evidently represent an altered condition of fine-grained tuffs which have been deposited in water. They are believed to be equivalent to the highest beds met with in the Meander Hills, subsequently described.

Anticline with two limestone beds.

Returning to the last-described limestone outcrop.—This is followed to the westward by an anticline about a mile and three-quarters wide, bounded to the west by what is taken to be another exposure of the same limestone, with westerly dips at high angles. On this western side of the anticline, below the limestone mentioned, is another limestone outcrop which, unless some unrecognized complication occurs, must represent a second and underlying bed. This was, however, not seen on the eastern slope of the anticline. The strata intervening between the two limestones appear to have a thickness of about 1000 feet, which is characterized chiefly by coarse green diabase-breccia or agglomerate; and where this runs out upon the lake shore, it contains in some places large quantities of angular pieces of limestone, holding crinoidal fragments, and otherwise resembling the limestones of this series.

Schistose rocks in anticline.

Beneath the lower limestone, in the central part of this anticline, a thickness of about 2600 feet of beds not elsewhere seen in this part of the section, come to the surface. They consist for the most part of bright leek-green altered diabases, generally distinctly porphyritic and

occasionally brecciated. Epidote has frequently been developed in the more compact varieties of this rock, but a large part of the entire thickness of these lower beds has been converted by pressure into green chloritic schists, between which and the compact forms transitional varieties occur. The schists are often highly calcareous, and it may be that the more calcareous beds have been those most affected by this alteration.

Second syncline.

In the next small syncline to the westward, beds recur like those already described as overlying the upper limestone. These are here, as before, often purplish in colour and largely agglomeritic.

Second anticline.

The next (and last) narrow anticline, to the westward, is belived to occur in the manner indicated, though the outcrop of the upper limestone which should appear on its west slope, was not seen. It seems that this anticline narrows and that its axis slopes down in a northerly direction, so that neither limestone comes to the surface on the lake shore, while the lower limestone can outcrop only to the south of the present line of section. In this anticline the rocks are again found to be rather schistose in character, in some places, particularly near the lake shore.

Western low syncline.

In the last low syncline, at the west end of the section, the exposures are very unsatisfactory, and its form as indicated is therefore largely conjectural. The characteristically purplish rocks previously noted were here not recognized, but green rocks of the usual character and often breccias are abundant on its eastern side, while the fine-grained felspathic materials forming the highest member of the section, appear to occupy a considerable breadth in its central part.

General character of rocks.

With reference to that part of the section in the vicinity of Nicola Lake, above described, the following general points may be noticed. The diabases of the Nicola series are here, in many places, unusually charged with epidote, a fact which may probably be attributed to the proximity of the granite mass which comes out on the north shore of the lake. A greater development of schistose structure is found here than elsewhere commonly encountered in the Nicola rocks of this part of the Interior Plateau, and this is most prominent in the anticlines, especially toward their axes, where the beds stand at very high angles and appear to have had their original structure broken down by the intensity of the pressure exerted upon them. The two limestone beds are so inconsiderable in thickness that they may never have been absolutely continuous throughout the area covered by the section, while the recurrent explosive forces indicated by the massive volcanic breccias may easily have destroyed or removed the limestone

beds locally. This, in fact, becomes more than a mere probability, in cases where limestone fragments in quantity are components of the breccias.

Section east of McDonald's River.

An endeavour has been made to continue the section above described eastward and northward through the Meander Hills and as far as the Douglas Lake granite mass, thus to connect the rocks of the Nicola Lake section with the dark fine-grained argillites and amphibolites which surround that mass. The result of this attempt is shown in the eastern part of the general section presented, but in this part of the section it must be understood that the data are very much less precise than in the case of the section along Nicola Lake. The syncline found in the Meander Hills, in which occur well bedded fine-grained felspathic rocks almost certainly identical with the similar rocks found to form the upper members of the series near Nicola Lake, may be described as the ruling feature of this part of the section.

Syncline of Meander Hills.

These upper beds are here confined to the higher part of the hills, south of the Upper Nicola, and do not appear in the valley of the river. They consist chiefly of fine-grained felsites, of gray, greenish-gray and blackish tints when freshly broken, but which weather to various rusty colours. Some varieties break with a perfect conchoidal fracture. With these rocks, especially toward the base of this part of the series, are some fine-grained diabases, while the highest beds seen, resemble hard black argillites and probably contain a considerable proportion of ordinary argillaceous material. All these rocks are well and regularly bedded, in layers ranging from less than an inch to several feet in thickness. Like the rocks of the upper part of the Nicola Lake section above described, they resemble very closely the felsitic strata found in the vicinity of the Cretaceous area near Ashcroft, elsewhere noted (p. 113 B).

Highest beds.

Underlying green diabases.

To the west of the syncline thus occupied, between it and the line of McDonald's River and the shore of the upper part of Nicola Lake, hard gray-green and leek-green altered diabases of the usual kind prevail. These are generally more or less porphyritic and occasionally very markedly so. In one place, west of McDonald's River, considerable exposures were found of a hard green amygdaloid of which the base is coarsely porphyritic with uralite crystals. It is difficult to ascertain the attitude of these rocks, but where this was observed, they appear to lie at low angles, being in some cases nearly horizontal. The granite shown to underlie these rocks in the section, does not appear at the surface on the line of section, but occupies a considerable area near the shore of Nicola Lake half-way between the mouth of the Upper Nicola and McDonald's rivers. The limestone

beds were not seen near the line of section anywhere to the east of McDonald's River, and may not be continuous in this part of the region.

To the east and north-east of the syncline, similar diabases are found in occasional exposures, till, on the north side of the Upper Nicola, below Douglas Lake, the underlying black argillites and amphibolites are reached.

In the subjoined recapitulation of the general section found in the vicinity of Nicola Lake and in that of the Upper Nicola River, the supposed order, with the approximately determined or estimated thickness of the various members of the section are given. These represent the Nicola formation, of which green diabases may be stated to be the characteristic rocks. The dark fine-grained amphibolites and argillites lie beneath the lowest beds included in this summary. Recapitulation of section.

It will be noted that no limiting horizon has here been ascertained for the top of the section, which merely ends upward with the highest observed beds in the region. Also, that the lowest member of the section includes only the thickness brought to the surface in the main anticline on the south side of Nicola Lake. It is highly probable that a much greater thickness of the beds of this member is included in the eastern part of the section, where its actual base appears to be found in juxtaposition with the great series of argillites and amphibolites. The thickness of this member may in fact reach 6000 feet or more, but as already explained, the data found as to the attitude of the rocks in this part of the section are insufficient.

The order of the annexed summary section is descending:—

	Feet.
1. Hard, fine-grained generally well bedded rocks, chiefly felsites; thickness seen in Meander Hills (about)	1,200
2. Altered diabase rocks, generally porphyritic, often brecciated; for the most part green but often purplish toward the base	2,600
3. Limestone (say)	50
4. Green altered diabase-porphyries, mostly coarse breccias	1,000
5. Limestone (say)	50
6. Green altered diabase-porphyries, often brecciated, occasionally amygdaloidal; thickness seen near Nicola Lake (about)	2,600
Total	7,500

Nicola formation to the south of Kamloops Lake and between the Moore Creek granite-mass and Guichon Creek.

The largest connected area believed to be occupied by rocks of the Nicola series, is that which runs southward from the middle part of Kamloops Lake to the edge of the map-sheet. This has a Great area of Nicola rocks.

length of about forty miles, with an average width of perhaps twelve miles. It includes parts of the Timbered Hills, the valley of Meadow Creek, the Little Timbered Hills, and continues beyond the southern edge of the map to the Nicola River. The eastern and western sides of this area are formed in great part by granitic masses, but it is elsewhere bounded by overlapping Tertiary rocks. Though so extensive, but little detailed information respecting this tract of the Nicola rocks has been gained. It is for the most part densely wooded, and has therefore been examined along a few lines only, and then with difficulty. This being the case, it will be necessary merely to summarize the observations made.

Rocks near Jacko Lake

From six to eight miles south of Kamloops, a projecting arm of the area of Nicola rocks above referred to, occurs in the vicinity of Jacko and Edith lakes. The country is here open and the exposures are fairly good. To the south of Peterson Creek, in the valley up which the trail going toward Trout Lake is shown to run, these rocks were examined with some care. They consist here for the most part of hard green diabase-tuffs, which in some cases show their bedding very clearly on weathered surface, but in others can scarcely be recognized as clastic till microscopically examined. Diabase agglomerates are also found, as well as some beds which appear to represent effusive materials of the same composition. These rocks dip north-eastward at angles of 45° to 60°. Their strike, if traced out to the south-eastward, appears to show that they represent the rocks met with to the north-west of Stump Lake (p. 128 B) which they resemble. They also closely resemble rocks seen to the east of the upper part of Moore Creek and to the south-east of Stump Lake (p. 130 B).

Relations to other exposures.

Contact with granites,

On approaching the granitic area to the south-westward, these rocks become more or less markedly schistose. Near Peterson Creek, above Jacko Lake and about where the 3000-foot contour-line is shown to cross it on the map, gray and greenish, somewhat micaceous schists occur. On the west side of the creek, two or three miles further up, similar schists were found, together with some massive green diabase and rather extensive exposures of a peculiar green spotted schist, which in the large scale shows evidence of having been a diabase agglomerate. The actual junction with the granitic rocks was not seen, owing to the amount of drift covering, but the alteration seems to have extended further than usual from the intrusive mass. The foliation of the schists is not always parallel to the bedding, but is everywhere roughly parallel to the edge of the granite.

*Appendix I., No. 34.

Along the stream which drains Edith Lake into Peterson Creek, the diabase rocks are likewise much altered, being here near the margin of the granitoid or gabbro mass which runs from Cherry Bluff to Coal Hill and thence south-eastward. They were not, however, on this side observed to assume a schistose character, the appearance being rather that of a passage of the greenstones into the granitoid material. Edith Lake.

Further to the west and north, on Alkali Creek, a couple of exposures of limestone were found, in which crinoidal remains were noted. They are much broken up and full of felspathic or siliceous material, but may be assigned with little doubt to the Nicola. Between these and the southern edge of the Tertiary volcanic rocks as marked on the map, crushed and highly silicified rocks, often pyritous, were seen in several places. It is impossible to tell the original character of these, but they also are assigned to the Nicola formation. Their alteration is probably connected with a line of fracture and disturbance which appears to run through from Copper Creek. Specimens of these pyritized rocks subjected to assay proved to contain no gold or silver. Rocks on Alkali Creek.

Between Duffy Creek and Three-mile Creek, to the south of Kamloops Lake, an extensive area is occupied by rocks referred to the Nicola formation, but although considerable attention was devoted to these rocks, it has been found impossible to attain any certainty as to their arrangement or thickness. There is some evidence to show that an important fault cuts the lake-shore about half-way between Six-mile Point and Three-mile Creek, running a few degrees east of south, and marked by a massive dyke of dark green-gray dolerite which forms a bluff on the lake a short distance west of the 229th mile-post on the railway. In this bluff a large fragment of conglomerate and limestone has been caught up, as described in my report of 1877.* Between Duffy and Three-mile Creeks. Fault.

To the eastward of the line of the supposed fault, the general dip of the Nicola rocks appears to be easterly, but they are as a rule very massive. So far as made out, the lowest beds well exposed are those between Six-mile Point and the fault; and about a mile west of the point, in the hills south of the lake, a rather interesting development of exceptionally well bedded rocks occurs, D. N. 60° E. < 60° These include at least thirty or forty feet of shaly beds, resembling argillites, of black and dull greenish colour, but evidentally composed chiefly or wholly of tuffaceous material. They are interstratified with hard, greenish agglomerates, and with some soft fine-grained agglomeritic beds of a gray colour, in which some of the small frag- Rocks east of fault.

* Report of Progress, Geol. Surv. Can., 1877-78, p. 118 B.

ments appear to be partly rounded by water action. These reappear about two miles to the south, on the wagon-road, where it skirts a small lake. The argillite-like beds resemble some found on the north side of Kamloops Lake to the west of Copper Creek.

Above and to the east of this well bedded zone, is a great mass of greenish, gray and sometimes purplish diabases, with little trace of bedding, but largely composed of agglomerates and hard tuffs. The latter are notably abundant in this region, they form a large part of the ridge of hills which runs south-eastward from Six-mile Point, crossing the wagon-road and then skirting it to the south all the way to Duffy Creek. A representative specimen of this material, collected near the 232nd mile-post on the railway, is described in the appendix.*

The rocks above described, seem to represent the upper rather than the lower part of the general section as shown south of Ashcroft, and may have a thickness of 5000 or 6000 feet.

Rocks west of fault.

To the west of the line of fault, and between it and Three-mile Creek, the strata appear to have a general westerly dip at an average angle of perhaps 30°. This is best seen in general views of the hills from the north side of Kamloops Lake, the beds themselves presenting the usual difficulty on the ground. The mass of the rocks consists chiefly of diabase-agglomerates, here very often purple or purplish, but it includes one or possibly two beds of limestone, of which the thickness must be fifty feet or over in places. No fossils but obscure crinoidal remains could be found in the limestone outcrops. Two miles east along the wagon-road from Three-mile Creek, and near the supposed line of the fault, some small exposures occur of a limestone charged with well rounded small siliceous pebbles, apparently derived from the Câche Creek rocks. This dips westward at an angle of 20°, but its relations to the neighbouring rocks could not be made out. Between this outcrop and Three-mile Creek, it is possible that one or more small outliers of the Oligocene conglomerates remain, but some little exposures which were suspected to be of this character could not be clearly separated from the Nicola rocks.

Upper valley of Three-mile Creek.

Further up the valley of Three-mile Creek, on the east side, for about nine miles back from the lake, numerous exposures of rocks of the Nicola formation were examined. They are all much disturbed and very irregular, and offer no features requiring special mention, although the limestone appears to run on in this direction and some of the agglomerates (often purplish) are charged with numerous lime-

* Appendix I., No. 31.

stone fragments. Similar diabases and diabase-agglomerates, but generally green, were found in the hills near the head of Duffy Creek.

It is very probable that a second important line of faulting follows the valley of Three-mile Creek.

Mention may be made here of a remarkable vein of siliceous dolomite which traverses these rocks near Duffy Creek. This appears to begin about one mile and a half south of the 233rd mile-post on the railway. It runs thence south-eastward along the slope of the hills for a couple of miles, to Duffy Creek, where it turns to a south-westward course, and was followed by Mr. McEvoy for about two miles further, along the north-west side of the creek. The vein is often a quarter of a mile in width, and, as specimens collected from it yielded a trace of gold on assay, it may be worthy of further examination. It precisely resembles in character the dolomite veins elsewhere found in this district, as, for instance, those of the southern part of the Garde Lafferty near Kamloops, but is much larger than any of these. It is probably referable to the same date with the other similar veins, and this, there is reason to believe, is later than that of the oldest Tertiary deposits (p. 163 B).

Dolomitic vein.

Traces of gold.

Near Savona, the rocks are chiefly green diabase-agglomerates, often notably coarse and porphyritic.

Savona.

About the head waters of Cherry Bluff Creek, greenstones of the usual character are found, but there is here also a small area of a diorite-like rock which is pretty evidently an intrusive mass, and is therefore indicated on the map under the same colour with the plutonic rocks generally.

Cherry Bluff Creek.

The tract forming the south-west slopes of the Timbered Hills, with the plateau country southward to Meadow Creek, was examined along the exploratory line shown on the map and along the valley of Meadow Creek. The whole upper part of this valley, is wide and deeply filled with drift deposits, showing only here and there small isolated exposures of the underlying rock. The west edge of the granite, near Trout Lake, is entirely concealed, but near its assumed position green, schistose and slightly micaceous, much altered, diabase was found. This resembles some of the rocks seen in similar contiguity to granite on Peterson Creek (p. 138 B). Elsewhere along the valley, the rocks seem to consist of green and gray-green, with occasionally purplish, diabases, which are sometimes agglomeritic, but present no features of special interest. On the north side of the valley, three miles east of Guichon Creek and to the east of the

Valley of Meadow Creek.

projection of Tertiary volcanic rocks which occurs there, brownish and purplish grauwacke-like volcanic ash rocks are found, much like those of the vicinity of Three-mile Creek already described (p. 139 B).

Choo-whels Mountain.

On the route from Trout Lake to Choo-whels Mountain, nearly all the rocks seen are greenstones of the usual character, which seldom show distinct bedding, though often consisting of coarse or fine diabase-agglomerate. In a few places the diabase was observed to assume a slightly schistose character. One of the agglomerates contains numerous fragments of limestone, most of which has been converted into greenish or reddish marble. Some of these are large and still show distinct traces of crinoid stems and other very obscure fossils, generally silicified. There are also some rounded pebbles present, which appear to show contemporaneous water action.

The southern point of Choo-whels Mountain, which was occupied as a transit station, is composed of a dark leek-green augite-porphyrite, somewhat less altered in appearance than most of the rocks of this region. From this point to Face Lake, diabases are seen in numerous exposures. These are usually greenish, but include also a notable proportion of purplish or reddish rocks of the same character.

Greenstone Creek.

Similar rocks prevail along Greenstone Creek, but they are here nearly all green or gray-green in colour. About a mile and a half below Big-fish Lake, on this creek, where its valley makes a right-angled turn to the south, there are, however, some exposures of rocks differing in character. These are gray or blackish in colour, well bedded in thin layers, and are found on microscopic examination to be composed of siliceous and tuffaceous matter intermixed.* Macroscopically they much resemble some rocks noted near Peterson Creek (p. 138 B). In certain layers they contain numerous small calcareous fragments, and with these rocks there appears to be associated some slaty or schistose argillite, though this was not actually seen in place. The dips are eastward, at rather high angles. It appears not improbable that the horizon here represented may be the same with that of the argillites noted in the hills to the north of Savona (p. 121 B) though no fossils were found at this place.

Rock south of Meadow Creek.

Several excursions were made from Meadow Creek into the country to the south, but this is not only for the most part thickly wooded, but also heavily drift-covered. These difficulties are especially great toward the edge of the granite on the east, and about the head of the west branch of Moore Creek, so that the line between the Nicola rocks and the granites in this region is far from being very definitely fixed.

*Appendix I., No. 36.

In the rocks met with to the south of Meadow Creek, the only notable feature is the unusual abundance of amygdaloidal diabase-porphyrites, which are sometimes green, but more commonly purple in colour. These are comparatively little altered. The amygdaloidal cavities are often nearly spherical and are filled chiefly with zeolites together with some calcite.* Rocks of this class appear near Meadow Creek about four miles above its mouth, and run thence in a south-easterly direction, gradually departing from the line of the stream, for about six miles. They closely resemble the purplish amygdaloids found not far above the limestone on McDonald's River (p. 133 B) and though the attitude of the beds could not be determined, it is possible that they dip eastward or north-eastward and pass beneath the rocks last described on Greenstone Creek, in which case the section here might be found to repeat the conditions of that observed between the Deadman River and the summit of the hills north of Savona (p. 121 B).

Near Mamit Lake.

Among masses of rock brought down by a stream which enters Guichon Creek from the east between Meadow Creek and the head of Mamit Lake, gray fine-grained limestone with obscure traces of fossils was found. This was seen to be associated in the same fragment with greenstone rocks, and it is probable that an outcrop of one of the limestones of the Nicola formation occurs to the east of Guichon Valley not far from this place. It may further be observed here, that some evidence of the probable occurrence of a small outlier or outliers, or of intrusive masses of Tertiary volcanic rocks was met with in this vicinity, though no such rocks were actually seen in place.

Possibly Tertiary area.

Ray Creek.

Further south, on Ray Creek, the rocks seen all belong to the greenstone series. They are hard and often contain some epidote, and are generally much shattered by jointage planes. Similar rocks appear to characterize the whole region in this vicinity. At the extreme head of Clapperton Creek and on the adjacent crest of the Little Timbered Hills, where the Nicola rocks form a bay in the edge of the granite, they are found in various stages of alteration, sometimes resembling diorites, and elsewhere, near the actual border of the granite, becoming gneissic in appearance or forming thinly foliated and highly micaceous schists. The strike is here, locally, nearly east-and-west. Small quartz veins are frequent in these altered rocks, and they are also cut by granitic veins or dykes. On the lower part of Clapperton Creek, the rocks are seldom well seen, but they appear to consist wholly of diabases or associated materials, generally greenish. To the west of Clapperton Creek, along the border of the projection of Tertiary rocks shown on

Clapperton Creek.

*Appendix I., Nos. 24 and 27.

the map, the Nicola series is represented by bright greenish amygdaloids and agglomerates, the latter passing into tuffs, and then becoming somewhat calcareous. On the west side of the same projection, the underlying rocks, where seen, consist of brown and purple-brown augite-porphyrite, with abundant felspar crystals and a little quartz. These are elsewhere referred to in connection with their relation to the Tertiary rocks (p. 195 B).

Junction with granites on Guichon Creek.

The wide and deep hollow now occupied by Guichon Creek, like the corresponding depression of Moore Creek, has been excavated along the line of junction of the Nicola rocks with the granite. Its existence has undoubtedly been determined by that of this junction, and although the stratified rocks are usually hardened on their approach to the granites, it may be supposed that the facility of excavation evidenced has been due to the much shattered state in which these rocks are often found when thus situated. In general, this valley is now deeply filled with drift deposits, but sufficient exposures of the older rocks have been found to enable the line of junction to be traced with approximate accuracy. Opposite the mouth of Meadow Creek, along the base of the hills which border Guichon Creek valley, the actual contact of the Nicola rocks with the granite is pretty well seen. The diabases become schistose and almost gneissic in appearance, while the margin of the granite itself has been crushed into a foliated material of gneissic aspect and gray colour. It was also observed here that the granite, at some distance from its actual edge, is charged with angular fragments of the greenstones, still plainly distinguishable from it.*

A great area of greenstone.

Speaking generally of the large area of rocks of the Nicola formation to which the foregoing brief notes apply, it may be described as being characterized throughout, so far as our present knowledge goes, by altered volcanic products. It is in fact a great region of "greenstone," which is usually found to have the composition of an altered diabase, and often appears in the form of agglomerates, sometimes as amygdaloids, and occasionally as fine ash rocks or tuffs.

Limestone and argillites.

The occurrence of limestone, as near Three-mile Creek, and of argillite-like materials, as on Greenstone Creek, with the evidence of underlying limestone afforded by the calcareous agglomerate of the south-east slope of Choo-whels Mountain, are quite exceptional. These at the same time must be regarded as most important exceptions, for they appear to offer a means of eventually determining and tracing out horizons, and of bringing these into comparison with those recognized on Nicola Lake and elsewhere. The attitude of the beds is so

* *Cf.* Annual Report Geol. Surv. Can., vol. II. (N.S.), p. 11 B.

seldom observable, that the order and thickness of the series here remains indeterminate. The structure appears, however, to be in the main a synclinal one, resting between the eastern and western granitic masses. The general direction of strike seems to be about N. 40° W., and the highest beds found are probably those of the vicinity of Big-fish Lake. The general synclinal structure, if such it be, is, however, evidently complicated by several superposed minor folds, but no evidence has been discovered of acute crumpling or of great disturbance, except in certain places toward the edges of the area. General structure.

Rocks of the Nicola formation, seen on and near the Upper Deadman River.

Passing over the region in the vicinity of the Thompson River above Ashcroft, and that of the western part of Kamloops Lake, a description of which has already been given in connection with one of of the general sections, (p. 115 B) it remains to add a few words respecting the older rocks shown along the northern part of the Deadman River and its branches where these streams have cut through the Tertiary volcanic strata. The rocks thus shown are believed to be referable to the Nicola formation.

The valley of Criss Creek, for about ten miles above its junction with that of the Deadman, appears to be continuously cut down to and into, the older rocks. These, so far as observed, and with the exception of one thin bed of limestone near the lower part of the creek, consist entirely of greenstones and porphyrites, and are probably for the most part diabases in composition. In colour, they are green, gray and blue-gray. Criss Creek.

Two miles above the mouth of Criss Creek, the main valley of the Deadman is found to be floored by greenstones, which continue along it for about a mile and a half. These, according to Mr. McEvoy, are dark green diabases. After a short interruption caused by Tertiary rocks extending across the valley, the older rocks are again found, and they continue in the bottom of the valley for above eight miles, or nearly to the lower end of Deadman Lake. Just about the mouth of Gorge Creek, extending thence up stream for a distance of about a mile, is a hard breccia or sub-angular conglomerate, composed chiefly of greenstone fragments with some of granite and of fine grained limestone. This has a calcareous cement, and is somewhat different in character from the conglomerates usually met with, resembling the rock seen east of Three-mile Creek (p. 140 B). It is followed to the north by an ordinary dark green diabase-agglomerate ; and rocks of Deadman River above Criss Creek.

the same character, though often apparently massive rather than agglomeritic, continue to floor the valley to the point above designated, where the Tertiary rocks again extend completely across it.

To the north of Deadman Lake, the old rocks reappear in the bottom of the valley and seem to be continuously shown, according to Mr. McEvoy, for more than seven miles. They consist of greenstones, differing from those seen further down the valley only in being somewhat more highly indurated and altered. They become coarsely crystalline on approaching the edge of the great granite region on the north.

Bonaparte River.

In this vicinity, a few miles to the north-westward, on the Bonaparte below the mouth of its north branch, a small area of fine-grained green diabase was observed to occur in the river-valley, between the margin of the granite and the overlapping edge of the Tertiary rocks on the west.

Uren's.

Following the main stream of the Deadman to the eastward, above Hunters Creek, it would appear that the volcanic rocks of the Tertiary have been removed for a considerable area near Uren's, as marked on the map. This area seems to be occupied in part by bedded greenstones, in part by diorite, but it is so heavily drift-covered that its extent as well as the relative proportions and outlines of the two classes of rocks are doubtful.

Granite Lake.

Still further up, the valley, for a distance of nearly three miles below Granite Lake, is again floored by old stratified greenstones, which, so far as their attitude could be observed, appeared to strike about east-and-west and to be nearly vertical. These rocks are sometimes more nearly blackish than greenish in colour, and appear now to be fine-grained diorites rather than diabases. They are occasionally schistose, and probably owe their present appearance to their proximity to the great granitic mass of the Bonaparte Lake region. Granite Lake is itself surrounded by granitic rocks, but in these, on its south shore, are numerous large fragments of greenish dioritic rock, with some of hornblende-schist, the appearance being that frequently characteristic of the vicinity of the border of the granitic masses where they meet the stratified greenstones. It is entirely doubtful whether the greenstones found in this particular area should be classed with the Nicola formation, as no definite evidence as to their age could be obtained.

Cretaceous Rocks.

Fraser River Area.

The principal area of Cretaceous rocks included in the Kamloops sheet, takes the form of a narrow band, which, entering the southern edge of the map, pursues a remarkably direct course of about N. 20° W. till it passes obliquely across its western edge. The whole length of this band, within the map, is about fifty-six miles, its greatest width about seven miles. It may be regarded as defining the inner or eastern margin of the wide mountainous zone formed by the Coast Ranges. In a general way, it must be understood to occupy a syncline on the eastern side of these ranges; but its occurrence there is also, no doubt, largely due to faulting, parallel to its general direction. The actual position of the Fraser River, within the limits of the map, has evidently been determined chiefly by the existence of this Cretaceous band, or by the folding and faulting which have here defined it. For a distance of over forty miles, from the mouth of Bridge River to the southern edge of the map, the Fraser almost exactly follows the main strike of the Cretaceous rocks. Above Bridge River it breaks across the Cretaceous belt, and thereafter, to the western edge of the map, its valley lies to the eastward of this belt.

General relations of Fraser River area.

From the southern edge of the map, as far north as the mouth of the Thompson, the Cretaceous rocks are chiefly represented on the west side of the Fraser. The main direction of strike is generally nearly parallel to that of the valley, but to this there are numerous exceptions. The beds are much disturbed and broken, and probably consist of several crushed folds, as dips occur both in eastward and westward directions.

Region south of Lytton.

The rocks are chiefly greenish and gray-green, hard grauwacke or tuffaceous sandstones, with some conglomerate and a little shaly argillite. Where crossed on the route to Kl-ow-a Mountain, the Cretaceous rocks have a width of a mile and a half to the west of the Fraser, but between this point and Stein Creek their width has not been accurately determined.

On Stein Creek, the Cretaceous rocks have a width of nearly two miles to the west of the Fraser, occupying not only the flat land near the river, but forming also the lower tier of hills along the base of the main range. Sandstones and shaly beds of the usual character prevail; but in this vicinity, on both sides of the river, entire masses of the rocks have become reddened and decomposed by action subsequent

On Stein Creek.

to their deposition. The beds are all much shattered, and lines of faulting in this place undoubtedly run along the valley, one of which apparently bounds the Cretaceous trough on the east side of the valley. The conglomerates here hold rather more granitic material than usual.

Freshwater fossils.

Below the bridge on Stein Creek, where the rocks are several times folded, a bed of gray, crumbling, sandy shale was found to contain numerous fossils. These are, unfortunately, badly preserved, but are apparently fresh water forms, one of which may be a *Goniobasis.* Some fragments of large fin-spines of a Selachian fish were also found, measuring more than half an inch in greatest diameter, and either nearly triangular or laterally compressed in cross-section.

Fossil plants.

On the east side of the Fraser, about a mile above the mouth of Stein Creek, numerous exposures of Cretaceous rocks occur in a number of transverse gullies which are crossed by the trail. Blackish, shaly, and evidently carbonaceous beds, are here somewhat more abundant than usual, and from these a few fragmentary plant remains were collected in 1877, and a somewhat better, though still very small, collection, was made in 1890. Sir J. Wm. Dawson has described the first collection as containing two indeterminable dicotyledonous leaves and one flabellate leaf resembling that of a *Salisburya.** On the second collection, he supplies the following note :—

"1. *Platanus obtusiloba*, Lesq., or closely allied. This is a species found in the Dakota group in Nebraska.

"2. Probably *Magnolia tenuifolia*, Lesq., which is found in the Dakota of Nebraska and also in the Dunvegan group of Peace River.

"3. *Menispermites*, allied to *M. grandis* of the Dakota group, but probably specifically different.

"4. *Laurophyllum.* Several leaves referable to this genus, and near the Dakota species.

"5. *Sequoia*, a fragment which may be *S. Rechenbachii.*

"6. Grass-like stem or *Phragmites*, *Carpolites*, etc.—scarcely determinable.

"The whole probably belongs approximately to the age of the Dakota group or near to this."

Stein Creek to La-loo-wissin Creek.

Further up the Fraser Valley, the principal devolopment of Cretaceous rocks continues to lie to the west of the river as far as La-loo-wissin Creek, and these often rise into hills of 2000 to 3000 feet in height on the flanks of the mountains there. The rocks met with are

* Report of Progress, Geol. Surv. Can., 1877-78, p. 110 B.

all so much like those already described, that it is unnecessary to enter into any detail respecting them. Evidence of great disturbance and crushing are everywhere found in the shattered condition of the beds, the recurrence of reddened zones, and occasionally of friction, or crush-breccias.

Beyond La-loo-wissin Creek, the greater part of the Cretaceous belt lies to the east of the Fraser River, though detached selvages continue to appear on the west bank also. In one of the latter, three miles above In-tl-pam Creek, numerous specimens of *Aucella Mosquensis* var. *concentrica* were found, in a hard black flaggy argillite. These are all considerably distorted by pressure. At this place and in the next considerable strip of Cretaceous on the west side of the river, near Texas Creek, hard, black argillites and fine grained blackish sandstones are more than usually abundant, and it is probable that the lower part of the formation, corresponding with that seen near Lillooet and Bridge River, is here chiefly represented. Thence to Texas Creek.

At the mouth of Texas Creek, below the bridge, cliffs are found composed of completely shattered black Cretaceous argillites, in which the fragments have since been re-cemented by the introduction of ferruginous material. These rocks have evidently been shattered in place, and they may be regarded as representing a species of friction-breccia. The shattered zone, which is of considerable width, crosses the Fraser River to the southern end of the Great Rock-slide, this remarkable feature being in fact due to the comminuted character of the rocks which have supplied its materials. Breccias at Texas Creek.

Fountain Ridge, appears to be entirely composed of Cretaceous rocks, bounded by the newer volcanic rocks of the Tertiary on the east, along the line of the Three-lake Valley and by Palæozoic rocks on the west; the line here nearly coinciding with the Fraser, till in the vicinity of Lillooet it crosses the river obliquely and includes the north-eastern slopes of McLean Mountain. The general structure of Fountain Ridge is that of a syncline, which appears to be simple in its southern part, but becomes wider and more irregular and complicated to the north. More or less faulting is suspected to exist along both the eastern and western borders of the Cretaceous, evidence of which seems to be given by irregularities of strike, and the broken and often silicified character of the rocks in many places near these lines, as for instance in the neighbourhood of the bridge at Lillooet. Fountain Ridge.

Some miles above Lillooet, the Fraser River breaks completely across the belt of Cretaceous rocks, from east to west, a circumstance Rocks above Lillooet.

probably due to the existence of an imperfect transverse anticlinal flexure, by which the rocks here appear to have been affected ; but though both sides of this part of the river have now been examined, the irregularities found are such that no really satisfactory general section has been obtained.

About half a mile north of Lillooet, rocks evidently belonging to the Cretaceous series, consisting of hard, blackish argillites, are found. Further north, near the Lillooet Bridge, similar rocks occur, in association with blackish quartzites, and materials of the same kind continue along the west side of the Fraser to the mouth of Bridge River. These are usually blackish, gray or greenish well-bedded quartzites, often much shattered and pyritized, and thus producing by weathering, bands of a rusty colour. These rocks, between Lillooet and Bridge River, have, as a rule, easterly dips, at an average angle of 60°, but varying from about 50° to vertical. They are all very much disturbed and irregular and have been highly silicified.

Bridge River.

At the mouth of Bridge River, where a considerable area has been stripped of its superficial deposits by placer miners many years ago, extensive exposures are found of black, gray and banded quartzites, with hard, black, shaly beds, and some thick layers of gray-green sandstone which pass into fine conglomerates. Bands of pyritized rusty rocks run both with and across the strike, which is here pretty uniformly S. 25° E., the beds standing vertically. The valley of Bridge River has been cut out along the strike of these rocks, as far as the edge of the present map and further. The beds found along it are either vertical or have high north-easterly dips ; but in the hills to the north-east of the river, the angles are lower, and hard, greenish-gray sandstones and conglomerates prevail. At the summit of the mountain ridge which runs parallel to Bridge River on that side, these dips become reversed, and the same beds occur in nearly vertical attitudes.

Transverse section above Bridge River.

A short distance above the mouth of Bridge River, what is pretty evidently a compressed anticline crosses the Fraser, and in this, blackish beds are again seen. This is followed to the eastward by a second syncline, of which Fountain Peak, forming the northern and culminating point of Fountain Ridge, occupies the central part. All the higher parts of this peak and its dependent range appear to be composed of the greenish-gray hard sandstones and conglomerates.

Mouth of Fountain Creek.

To the east of the peak, near the lower part of Fountain Creek, varying and confused dips are again found. In the gorge at the mouth of the creek, the beds dip away from the stream on both sides,

and it at first seemed probable that here an unconformable overlap of Tertiary sandstones occurred, upon upturned Cretaceous beds ; for the strata on the east side are comparatively soft and crumbling, while those on the west side have the usual hardened character of the Cretaceous rocks. It appears certain, however, that on the east side of the gorge a compressed and partly overturned anticline occurs, that the rocks on both sides are Cretaceous, and that the less indurated character of those on the east side is due to subsequent decomposition effected by acid vapours or by some form of solfataric action consequent on the volcanic eruptions of the Tertiary period.

To the east of Fountain Creek, Cretaceous rocks, generally sandstones, are found in various stages of alteration, but with low southerly dips. They are here not only much shattered and reddened, but also as a rule highly silicified ; and it was in consequence of the changes thus produced in their appearance, that no precise line was discovered between them and the distinctly volcanic rocks next met with, in 1877, when it was supposed that the latter constituted an underlying part of the same Cretaceous formation. A more detailed examination of the region, in the light of further study of the formations elsewhere, has since afforded grounds for reversing this opinion. Silicified Cretaceous rocks.

Thus, speaking generally of the Cretaceous rocks of this area, it may be said that they consist of highly indurated sandstones, argillites and conglomerates. The sandstones are most commonly of greenish-gray colours, passing on one hand into coarse, distinctively green rocks, largely composed of arkose materials derived from the older greenstones and granites, on the other, with fine-grained blackish sandstones which grade down imperceptibly into argillites of the same colour. Few of the sandstones are distinctly siliceous except where subsequently silicified, and many of them hold pebbles here and there. The argillites are generally black or nearly so, but often notably banded by lighter colours along the bedding planes and not seldom carbonaceous. The conglomerates are composed of well rounded pebbles, among which those of cherty quartzites and granitoid rocks are probably, as a rule, the most abundant, though greenstones, black argillites and phorphyrites are also represented, and limestone, though occasionally found, is notably scarce. Many of the rounded masses are as much as a foot in diameter. The paste of the conglomerates is, usually, a coarse-grained greenish grauwacke.* General character of rocks.

*A collection of pebbles, made from the Cretaceous conglomerates of Fountain Ridge, near the northernmost lake in the Three-lake Valley, has been macroscopically examined by Mr. Ferrier. The materials represented are, in order of importance, as follows:—Fine-grained eruptives of various kinds, diabases, diorites, granites, with one specimen of apparently an impure limestone.

Order of superposition.

Respecting the order of superposition of these beds, it may be stated that the blackish sandstones, quartzites and argillite form the mass of the lower part of the formation, while the greenish and gray sandstones and quartzites, with the conglomerates, characterize its upper parts, and constitute the higher crests of Fountain Ridge and other mountainous elevations. None of these rocks are, however, confined to the upper or lower parts of the formation, for blackish argillites occur at various horizons throughout and the same is true of the conglomerates.

A line of weakness.

The whole of this great mass of rocks, is here found crushed together in a series of rather strict folds on the eastern edge of the great elevation of the Coast Ranges, the area which they now characterize having, for some reason, proved to be the line of least resistance and minimum strength during one at least of the periods of Cordillerian folding.

Thickness of the series.

In respect to the thickness of the Cretaceous rocks, the best evidence to be found in the area of the Kamloops sheet, though admittedly very imperfect, is that obtained in this particular district. To the south of Lillooet, on the east side of the Fraser, the Cretaceous rocks form for some miles a great range of vertical cliffs, in which the beds have rather low easterly dips. These cliffs show sheer rock-faces of about 2000 feet, and these, taken in conjunction with the outcrops nearer the river, must represent a thickness of at least 3000 feet of strata. But an examination of the sections as a whole, shows that the rocks thus exposed can constitute but a portion of the entire volume, and indicates that this must exceed 7000 feet, while it is very probably 10,000 feet or more.

Pyritous zones.

The occurrence of pyritized shattered and now rusty zones in these rocks has already been remarked. This is not uncommon, and has attracted attention in consequence of the possible occurrence of gold in such zones, although assays made of a few of these materials have not shown the presence of any gold. Another interesting point, is the occurrence of granitic intrusions, of the nature of large dykes, in these Cretaceous rocks, a fact which shows that some at least of the granites of the region must be of post-Cretaceous ages (p. 241 B).* It may also be noted, that the green colour and arkose character of many of the sandstones, renders it occasionally difficult to distinguish them in broken or poor exposures, from the greenish tuffaceous rocks of the Tertiary on the one hand and from the tuffaceous greenstones of the older series (from which their material has been derived) on the other. This is especially the case along the Three-lake Valley, but the

Post-Cretaceous granites.

Outlines on map.

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* See Appendix I., Nos. 38, 39 and 40.

line of division as now established there, is believed to be practically correct.

Fossils.

The only fossils obtained in this part of the region are a few specimens of *Pecten (Syncyclonema) Meekiana*, found a short distance to the west of Fountain house.

Rocks north of Fountain.

To the north of the vicinity of Fountain, the Fraser lies nearly along the east edge of the Cretaceous for about five miles, after which this edge gradually leaves the vicinity of the river and runs up the wide valley of Red Creek. Hard greenish sandstones of the usual character are the most abundant rocks along this part of the Fraser Valley, though some carbonaceous shaly layers also occur, as well as beds of conglomerate. The dips are generally westward. At a short distance below Black Hill Creek, and thence onward along the river and trail, the sandstones are somewhat different in character. They are completely shattered and rubbly, apparently considerably decomposed, and almost entirely formed of paler, greenish-gray, arkose material derived from granitic rocks. The apparent decomposition of these rocks may of course be due to the fact that they have never been penetrated by the silicifying matter to which the general induration of the sandstones is attributable, but it is equally probable that they have been affected by emanations due to the Tertiary volcanic period, in the manner suggested in the case of the similar rocks at the mouth of Fountain Creek (p. 151 B). The shattered condition of the rocks is almost certainly due to their proximity to the zone of volcanic action, and is very probably accompanied by faulting. It is thus uncertain whether these softer and paler arkose rocks represent a special horizon, but they very closely resemble some of the Cretaceous rocks met with on the Skagit River in 1877.* Cliffs of these rocks, of striking appearance and boldness, occur about the mouth of Black Hill Creek.

At Black Hill Creek.

Red Creek.

Along the west side of Red Creek valley, the Cretaceous rocks form a rather bold escarpment, dipping westward, generally at high angles. They appear to consist almost entirely of gray-green sandstones, and in large part of arkose and not highly indurated beds, like those above described. The Cretaceous rocks of the Camelsfoot Mountains, to the westward of the Fraser and Red Creek, were well seen from distant high points, but have not been examined in detail. The dips appear generally to be comparatively low in the central parts of this range.

Botanie Creek Area.

Botanie Creek area.

The small detached area of Cretaceous rocks shown to occur near the mouth of Botanie Creek, about two miles from Lytton, consists of

* Report of Progress, Geol. Surv. Can., 1877-78, p. 106 B.

blackish and brownish shales, hard gray sandstones, and conglomerates, all much disturbed. The conglomerates particularly, are also completely reddened, while the other rocks are generally shattered and slickensided. These beds, on the east side, are evidently faulted down against the granitic rocks, while a second fault probably runs along the west base of the small, scarped granitic ridge which is a prominent feature from the river. The actual area of the Cretaceous beds here is indeterminate, for they may extend further up the Botanie Valley than is now known, beneath the flat terraced land which occurs in it. A few small fragmentary fish-bones were here found in some of the shales, with what are apparently the crushed tests of minute *Ostracoda.*

Ashcroft Area.

Ashcroft area. This Cretaceous area may be referred to as the Ashcroft area, the town and station of Ashcroft being situated nearly in its centre, in a comparatively wide and low tract of land which is dependent on the existence of the Cretaceous rocks. It is about four miles in average width, with a length of about eleven miles, and for the greater portion of this length the Thompson River follows its axial line.

General arrangement. The rocks consist of sandstones, conglomerates, and dark shales, the shales here apparently preponderating in the upper part of the series, and occupying in the main the central part of the area, while the sandstones and conglomerates are more abundant and characteristic in the lower parts. There is, however, throughout, a considerable amount of alternation of all three classes of rocks, and no easily defined line of separation has been observed in the entire series.

Sandstones. The general lithological character of the strata in this area is closely akin to that of those of the more important Cretaceous region of the Fraser Valley. The sandstones are usually greenish or greenish-gray in colour, being largely composed of débris of the underlying diabases and felspathic rocks, and seldom or never purely siliceous. They vary in texture from very coarse grits and grauwackes, to materials of which the constituents are indistinguishable to the unaided eye. In many cases they are extremely hard. Shales. The shales are blackish, and their sombre outcrop along the Thompson has given its name to Black Cañon. With the shaly part of the series, some nearly black sandstones occur, but it is also in association with the shales that the distinctively gray sandstones are usually found.

Conglomerates. The conglomerates were nowhere in this area observed in great thickness. Their material is very varied in origin, but like the grits,

into which their finer varieties pass, largely composed of diabase or felsite. Pebbles of cherty quartzite, granite and gray limestone, are also abundant in some places. The component fragments are often well rounded, but in some beds are angular and unworn. This is especially the case near the base of the series, which appears to have been rapidly built up of materials produced by sub-aërial waste of the older rocks of the vicinity.

Breccias.

Breccia-like rocks of this character, but slightly water-rounded, and somewhat calcareous, are well shown in the ridge to the east of the wagon-road on the west side of the river, about a mile south of Cornwall Creek. They rest directly upon a rather fine-grained purplish calcareous agglomerate, which is more compact than the Cretaceous rocks above it, and is almost identical in character with that described as occurring in the Nicola formation, near Penny station (p. 119 B). The lower agglomerate is here also believed to be referable to the Nicola formation. Similar breccia-like rocks are abundant near the margin of the Cretaceous in the valley of the Bonaparte, about three miles above the mouth of that river.

No fossils have been found in any part of this area, but its lithological identity with the Cretaceous of adjacent parts of the Fraser Valley, is sufficient to fix its Cretaceous age.

Structure.

The rocks are nearly everywhere much disturbed and crushed, and no satisfactory general section has been obtained of them. Nearly all the observed dips are to the westward, but as a rule those on the eastern side of the middle line of the area are comparatively low, ranging from 10° to 45°, while those of the western side are often at angles of 60° and from that to vertical. It is thus probable that the structure of the area as a whole is that of a syncline, of which the western limb has been more or less completely overturned by pressure acting from the west. There are, however, undoubtedly, minor folds, and numerous indications of faulting are also found. The thickness of the entire series may be stated as at least 5000 feet, although it is very possibly much more. (See Section No. 1).

Western border of the area.

On the western edge of this Cretaceous area, the following notes may be added :—From the vicinity of Jack's Creek northward, for a couple of miles, the margin of the Cretaceous appears to be formed by a coarse conglomerate, generally with very high westward dips. At the place already referred to, about a mile south of Cornwall Creek and on the wagon-road, the rocks are found dipping eastward at an angle of about 15° only. The breccia and conglomerate described here is greenish and gray, and is believed to lie at the actual local base of the

formation. Further north, on the Bonaparte, where the line of junction was next clearly seen in detail, both the Palæozoic rocks and the Cretaceous are nearly vertical, and faulting was suspected. That such faulting is probably not very considerable, is, however, indicated by the similarity of the beds of the Cretaceous here found near the contact, with the basal beds just alluded to. Still further north, on the west side of Câche Creek, just where that stream issues from the Tertiary escarpment into the wide Semlin Valley, gray Cretaceous sandstones were found dipping westward at an angle of 60°. They appear to rest unconformably on a gray, fine-grained and somewhat dolomitic limestone, which dips S. 45° E. to 45°. The limestone is associated with greenish schists and evidently belongs to the Câche Creek formation. It would appear that these old rocks came up on a small subsidiary fold or along the line of a fault, and that they form an isolated area within the main western edge of the Cretaceous.

Rocks near Câche Creek.

Basal conglomerate south-east of Black Cañon.

On the east side of the Thompson, near the river, the rocks of the southern edge of the Cretaceous area are found to have a nearly east-and-west strike, dipping at high angles, apparently crushed against the older rocks in several folds, and very probably faulted. Further back from the river, a small projecting area of the Cretaceous was, however, observed, in which the beds are inclined at an angle of about 20° only, with varied direction of dip. The exposures, though not large, are of unusual interest, as they appear to represent the actual local base of the Cretaceous at this place in a little disturbed condition. The lowest bed, seen at one place, is a rough breccia, composed almost entirely of granitoid fragments of a single kind. This passes upward in a few feet, into a conglomerate with well rounded pebbles of the same kind, the change being gradual, and the cement in both cases calcareous. The conglomeritic bed rests in one place upon a green altered diabase near the junction of the latter with a granite mass. At another, it apparently rests upon the limestone described as the highest member of the section on page 113 B. Above, the conglomerate passes into gray sandstones.

Tertiary Rocks.

Kamloops Lake and Vicinity.

Information embodied in section No. 5.

The shores of Kamloops Lake were somewhat carefully examined in 1877, and some account of the rocks, together with a general section, were given in the report for that year. In connection with the more detailed investigations since undertaken, further examinations have

been made, notably along the shores of the lake, but also in the neighbouring country. It was proved in 1877, that the best general section of the rocks is that afforded by the north side of the lake, the exposures being there more connected than elsewhere and the irregularity and disturbance of the beds less troublesome. The section now presented (Sec. No. 5) follows essentially the same line, and is based upon that of 1877, but with the addition of many new facts. It is now believed to represent, with proximate accuracy, the general structure and probable volume of the Tertiary and its component members in this vicinity.

Original depression near Kamloops Lake.

It would appear, that the original surface upon which the Tertiary beds have been laid down, was generally lower in the vicinity of the present position of Kamloops Lake than elsewhere in this part of the region. This is shown in part by the greater thickness of beds referable to the lower portions of the Tertiary hereabouts, and by the occurrence in the neighbourhood of various members of that part of the Tertiary not elsewhere found. These features are very clearly seen, in examining the Tertiary rocks southward along the valleys of Watching Creek and the Tranquille River, or in approaching the lake shore, northward from the vicinity of Coal Hill. It is not, however, supposed that the original depression thus indicated corresponded either in extent or trend with that now occupied by the lake. Considerable changes in the relative heights of various parts of the old surface must since have occurred, as shown by the inclinations imparted to even the later beds of the Tertiary itself, while further differences of level have resulted from faulting at dates later than that of the Tertiary beds represented here. It appears, in fact, to be now quite impossible even to determine in what direction the drainage of this part of the country discharged previous to the disposition of the Tertiary rocks.

Cherry and Battle Bluffs.

A reference to the map will show that Cherry Bluff, on the south side of the lake, with Battle Bluff and its connected rocks on the north side, form two halves of what must originally have been a single mass of eruptive rocks and much altered greenstones. These are included under the colour employed for the plutonic rocks generally, though they differ considerably from the great granitic or dioritic masses, which more characteristically represent the plutonic rocks of the region. But in the case of these particular rocks, as well as in that of several smaller areas of a like character, it has been found to be impracticable, with our present knowledge, to draw a line of division between them and the granitic

areas. They are closely associated with these, and resemble them also in regard to their relations with the older stratified rocks (see p. 246 B).

Their rocks.

The rocks of Battle and Cherry bluffs, consist chiefly of gabbro, diorite, mica-diorite and altered diabases-porphyrite generally, much decomposed and everywhere excessively shattered.* Epidote is abundantly developed in some places, and veins composed of magnetite, together with trap dykes of various kinds, frequently traverse the mass. The mass as a whole must be regarded as an intrusive one, or one which at least holds the same general relation to the older stratified rocks as do the granites, but it is probable that considerable portions of the older stratified greenstones have also become included in it and are now inseparable from it. On the north side of the lake, and resting on the north-west flank of the Battle Bluff rocks, there is, in fact, an area of hard purplish and gray diabases and diabase-tuffs still clearly referable to the Nicola formation (p. 119 B).

Probably mark a vent.

A great part of the Battle Bluff and Cherry Bluff mass, above described, must be regarded as a portion of the floor upon which the Tertiary formations rest; but its position relatively to that of the Tertiary rocks, by which it is completely surrounded, with many other circumstances, appear to indicate also that it marks the site of a focus of volcanic activity of the Tertiary period. This was suggested in my report of 1877-78, and appears to be sustained by further investigation.

Original mass of volcanic accumulations.

The higher and central parts of the volcanic accumulations which may be supposed to have orignated here, must have been situated directly above the middle of the present lake, but have since been removed by denudation, leaving now a proximately horizontal section of the old volcanic centre. There is, however, no reason to believe that the original volcanic cone was otherwise than obtuse in form, and, relatively to its area, low. The dips, (or slopes), of such of the peripheral volcanic beds as seem to have been least disturbed subsequently, show that it may never have attained a height of more than about 4000 feet above the present water-level of the lake.

Valley of the lake.

It is quite possible that volcanic explosions, or faulting and shattering of the rocks toward the close of the period of activity of this vent, may have assisted in producing the deep rift now occupied by that part of Kamloops Lake between Battle and Cherry bluffs. This must remain a matter of conjecture, but the position of the lake relatively to the old centre of eruption is a very remarkable one, and it is evidently in consequence of the formation of the hollow of the lake across

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* See Appendix I., Nos. 96, 97, 99, No. 100 represents a stratified rock, caught up in the intrusive mass.

the central part of the old vent, by some such exceptional circumstance, that the denudation of the volcanic cone has progressed from its central parts outwards, in a manner quite different to that seen in other cases.

Protrusion of basal mass.

It is also probable, that the old pre-Tertiary surface, including both stratified and eruptive materials, when it became penetrated and intersected in all directions by the deep-rooted channels of the Tertiary volcanic materials, was to some extent thrust upward in a dome-like form, giving rise to the nearly regularly oval slope of the present surface section.

Further evidence of a vent.

Besides the actual position and form of the Battle Bluff and Cherry Bluff mass relatively to the volcanic beds of the Tertiary, further evidence of the existence of a centre of vulcanism at this place is afforded by the extremely shattered condition of its rocks, their exceptionally decomposed character, and the existence of such minerals as epidote and magnetite in considerable quantities in them, all pointing to the presence here of some exceptional cause of disturbance and of rock decomposition. Much of the last mentioned effect may have been produced by solfataric action subsequent to the main period of activity, and this appears to have been extended to the olivine rocks of the vicinity of Copper Creek, resulting in their change to serpentines and to the deposition of cinnabar and copper there. The great number of trap dykes seen in some places, as for instance along the lower part of he Tranquille River, may also be referred to in this connection.

Great mass of coarse agglomerates.

Reverting to the general composition of the surrounding Tertiary volcanic materials, additional evidence to the same effect is given by the great thickness of very coarse agglomerates or volcanic breccias, showing the recurrent action of local explosive forces, and the inclusion among them of flows of molten matter of various kinds. These rocks are well shown in the great escarpment to the north of Battle Bluff and in smaller exposures in Dufferin Hill, near Kamloops, and their inspection leaves scarcely any reasonable doubt that they actually represent parts of the flanks of a volcanic cone.

The statement previously made respecting the existence of a depression in the vicinity of Kamloops Lake previous to the Tertiary period, cannot of course be maintained because of the exceptional thickness of beds of the character of those last alluded to, but depends chiefly upon the equally exceptional volume of evidently water-laid deposits chiefly formed of the finer volcanic ejectimenta.

Succeeding description chronological.

The foregoing remarks on the general conditions of deposition of the Tertiary rocks surrounding Kamloops Lake, have been made in order

to provide a clue to the geological features as a whole, and for the purpose of dispensing as much as possible with detail in what follows. The conclusions stated here result from much work in the field, as well as from the subsequent study of the specimens, notes and sketches accumulated, and if ultimately found to be subject to correction in some particulars, it is believed that they will in the main stand, although many additions may have to be made in future. It will now be possible to speak of the Tertiary rocks in chronological order, assembling in this way the observations made in various years, and over an extent of country some twenty-five miles in length by about ten in breadth. The older rocks, upon which those of the Tertiary period were deposited, will here be regarded together, merely as the floor upon which the latter lie.

Coldwater group Oligocene.

In a previous chapter of this Report, the several main subdivisions found to be applicable to the Tertiary rocks have been noted, and it has been pointed out for what reasons the lowest conglomerates and sandstones have been referred to the Oligocene, under the name of the Coldwater group, and are regarded as being separated by some lapse of time and unconformity from the lowest Miocene beds.

Basal conglomerates.

The lowest part of these conglomerates may be referred to as the basal conglomerate, merely for the purpose of convenience in describing its characters and supposed distribution. Rocks referable to the Coldwater group, are found only in certain parts of the area assigned to the Tertiary on the map, and even in these places the basal conglomerates are not always recognized and are sometimes clearly absent. These conglomerates are peculiar in the large proportion of material derived from the older rocks of the immediate vicinity in every case. They are generally dark-brown or greenish-gray in colour and vary much in the degree to which their constituents have been rounded by water action.

Conglomerates west of Kamloops Lake.

South of the Thompson River below Kamloops Lake, conglomerates of this character cap the lower hills for a distance of nearly eight miles. To the south they are in turn overlapped by Miocene volcanic rocks. They are here usually dark greenish-gray in colour, but often weather reddish. The pebbles are pretty well rounded, sometimes becoming boulders of as much as two feet in diameter, and comprising a considerable variety of greenstones of the underlying Nicola formation, as well as granitoid rocks of various kinds and some black cherty quartzites. With the conglomerates are gray and gray-green sandstones, moderately indurated, and in these some carbonaceous fragments were found at one place. The beds dip in various directions at low angles. They are often

very well stratified and the whole thickness displayed in various places probably exceeds 500 feet.

A specimen of these basal conglomerates, holding large well rounded pebbles, on assay proved to contain traces of gold. The specimen was obtained from outcrops about one mile south of the Thompson River, opposite the mouth of Deadman River. Traces of gold.

It is very possible that a small area of conglomerates of the same kind, occurs at a nearly corresponding level on the hills due north of Penny station, on the opposite side of the Thompson. Large drift fragments were noted here, but the formation was not actually observed *in situ*. To the south of Savona station, no conglomerates of this kind could be found, the Miocene volcanic rocks apparently resting at this place directly on the Nicola formation.

A small exposure of similar conglomerates occurs on the road along Cherry Bluff Creek, between Roper's and Hughes's. A thickness of about fifty feet is here seen, extending from the level of the stream to where it is covered by a purplish porphyritic agglomerate, assigned to the Miocene period. Both rocks are very much fractured at this place. The stones in the conglomerate are more varied than usual in character and include a few specimens of cherty quartzite. They are well rounded and sometimes as much as a foot in diameter. The area of conglomerate exposed at this place appears to be small, but it is quite possible that more exposures of the same kind may occur in the wooded and generally drift-covered area to the west of this part of Cherry Bluff Creek. Conglomerates. Cherry Bluff Creek.

Crossing the lake to the north side, we find one of the most important developments of the Coldwater conglomerates and sandstones running back nearly parallel to Copper Creek for more than ten miles, with an average width of about a mile and a half. In the immediate vicinity of the shore, these beds appear to be overlapped and almost entirely concealed by dark greenish augite-porphyrites and agglomerates of the Miocene. But a single small mass of the conglomerates appearing from beneath these was seen on the shore, the beds dipping S. 45° E. $<$ 60°, and themselves apparently resting upon rocks of the Nicola formation. Conglomerates and sandstones near Copper Creek.

There is much evidence of faulting and extreme disturbance in this vicinity and the details of the structure are by no means well understood. It is in fact supposed that several faults run nearly parallel with the belt of Coldwater beds, following their main strike, and in each case throwing the beds down to the eastward. It is probably in consequence of such faulting that the beds themselves are found to lie

at such high angles and to be sometimes even vertical. Such an effect is often seen in this region, even where the Tertiary rocks are generally undisturbed. The observed dips are in nearly all cases to the eastward, but towards the extremity of the formation, on Criss Creek, some westerly dips were noted and lower angles of inclination are more common.

From the above statements it will be gathered that the attempt to show the arrangement of the strata upon this part of the section is little more than diagrammatic and largely hypothetical.*

The conglomerate beds supposed to be the lowest in this place, show something of the same dark coloration and local character of material generally characteristic of those in that position. Higher up, and constituting the great mass of the rocks, are conglomerates with well rounded pebbles of moderate size and of light to dark gray or yellowish colour. With these are sandstones of similar tints, and both sandstones and conglomerates are preponderantly composed of cherty quartzites.

Cherty pebbles.

These quartzites (evidently derived from the Câche Creek formation) are not known to occur in places in this neighbourhood, and their great abundance in the mass of the conglomerates, shows conditions markedly changed in comparison with those during which the basal conglomerates were formed, and in which the material was conveyed by rivers from a considerable distance and thoroughly rolled in transit. The local restriction of these characteristically cherty conglomerates as compared with the greater spread of those referred to as the basal conglomerates, further indicates a narrowing of the area of deposition after the period in which the lower beds of the series, regarded as a whole, were formed.

Traces of gold.

A specimen of these conglomerates collected near their western edge, on the trail north of Kamloops Lake, again showed traces of gold on assay.

Outliers on Garde Lafferty.

The identity of the cherty conglomerates of this locality with those of Hat Creek and the Nicola is elsewhere referred to. In all probability they here represent the delta or flood-plain of some early Tertiary river having its sources to the westward, rather than beds formed along the shores of a large lake, which appears to be the most probable origin for the basal beds generally. The total thickness of the Coldwater beds in this vicinity, is undoubtedly very considerable, and probably exceeds a thousand feet.

To the east of the main edge of the Tertiary rocks, in the somewhat peculiar tract of country named the Garde Lafferty, which occupies

* See also Section No. 1.

the angle between the North and South Thompson rivers, two small outliers referable to the basal conglomerates of the Tertiary are marked on the map. Other small patches of the same kind may occur in this vicinity, for the surface is often heavily drift-covered, and the known outliers show a tendency to characterize hollows in the contour of the older rocks. The conglomerate is here composed of rather small, well rounded pebbles, of all varieties of the older rocks, and includes a good many fragments of quartz derived from veins. There are also occasional thin layers of hard quartzose sandstone. The lowest layers of the conglomerates are highly charged with dolomitic matter, much indurated, and weather to reddish and yellowish colours. A similar dolomitization of the lower layers of the Tertiary rocks is found in a number of places in the district. It is here accounted for by the occurrence in the older rocks, of numerous veins of dolomite, which evidently mark the conduits by which dolomitic matter found its way to the surface at some time in the later Tertiary period. The basal conglomerates, though here found so near the main eastern outcrop of the Tertiary, have not been seen in actual connection with that outcrop; but the line of junction of the two series of rocks is almost always covered by débris from the bold escarpment of the overlying volcanic rocks of the Tertiary. It is probable that the conglomerates occur along the base of the Tertiary outcrops in the vicinity of Pass Lake and Lac le Bois. Further south, to the east of Mara Hill, the Tertiary finds its limit at a fault, with downthrow to the west.

Dolomitization.

A specimen of the conglomerate from the Garde Lafferty showed no trace of gold on assay.

In many other places in the vicinity of Kamloops Lake, various higher members of the Tertiary series, lie directly on the surface of the older rocks, by overlap. This is the case for instance to the south of Dufferin Hill and about the Battle Bluff and Cherry Bluff mass. It is probably also the case in the valley of Cherry Bluff and Alkali creeks; but this part of the southern boundary of the Tertiary is so poorly exposed that its position as laid down on the map is little better than conjectural.

Overlap of higher members of Tertiary.

It will be seen that the Coldwater beds, here almost exclusively represented by conglomerates, are very irregularly and partially distributed, even in the comparatively small area about Kamloops Lake. They are wanting in some places, very inconsiderable in thickness in others, but very thick in the vicinity of Copper Creek; these differences being due to original inequalities of the pre-Tertiary surface and to the positions of rivers and lakes antecedent to the beginning of the deposit of

General distribution and character of Coldwater beds.

the great mass of the Tertiary. They show no evidence of contemporaneous volcanic action, such débris of igneous rocks as they include being referable to the underlying Palæozoic and Triassic strata. The beds here classed under this general term, may thus vary considerably in age, and some of them may represent a time long antecedent to the beginning of the period of Tertiary vulcanism. They are the traces of an epoch of erosion, which was in progress before the great period of Tertiary deposition had been inaugurated. The close resemblance of the cherty conglomerates of Copper Creek to those of Hat Creek, those of the Nicola near the mouth of the Coldwater and to those at a locality ten miles south of Nicola Lake (beyond the area of the Kamloops sheet), is, however, such as to lead to the belief that their deposit occurred synchronously and under precisely similar conditions (see p. 69 B).

Upper members of Tertiary.

The most satisfactory knowledge of the remaining members of the Tertiary series in the vicinity of Kamloops Lake, is that obtained by an examination of the sections about the eastern end of Battle Bluff and on the lower part of the Tranquille River.

As already mentioned, the coldwater Conglomerates (1) are here wanting.

Dolerite.

(2.) Resting directly on the flanks of the Battle Bluff mass and dipping away from it to the eastward and north-eastward at an angle of 15°, is a coarse gray dolerite, often regularly columnar and resembling a basalt, under which name it was noted in the report of 1877 (p. 117 B). This is 100 feet or more in thickness.

Tuffaceous beds.

(3.) Above the last, is a series of yellowish and bluish-gray, hard, thin-bedded and fine-grained tuffaceous shales and shaly sandstones. These hold numerous fragments of plants in a very poor state of preservation and some obscure fish remains were also found in them. The thickness of these beds is probably more than 200 feet near the lake shore, but their outcrop appears to narrow rapidly when followed north-westward and westward along the strike, till it disappears. This particular intercalation of water-bedded material was not certainly recognized elsewhere, though it is possible that it may recur in some part of the broken section along the south shore of the lake between the eastern end of Cherry Bluff and the head of the lake. It is probably quite local, and may represent the position of a small lake, held in for a time by the growing volcanic accumulations of the vicinity.

Dolerites and tuffs.

(4.) Overlying these stratified materials, are more dolorites, coarse grained at the base, but finer in the upper layers. These probably represent a series of flows of molten matter, and are arranged in beds of varying thickness, some of which are finely columnar. The thick-

ness represented by these flows at this place is at least several hundred feet and very probably as much as 1000 feet, in all. The strictly igneous flows constituting this series, pass above into water-bedded tuffaceous sandstones, largely composed of doleritic débris, in such a manner that it is difficult to draw a distinct line of division between the two classes of rocks.

(5.) The tuffaceous sandstones last mentioned, together with yellowish tuffaceous agglomerates, of which the material appears to be largely doleritic, constitute the next number of the section, with a thickness of at least 500 and probably of nearly 1000 feet. These appear, with dips of 10° to 15° to the eastward, where the Tranquille River issues from its narrow valley to the head of its delta-flat, at a distance back from the lake-shore of about half a mile. A short distance further eastward, they flatten out, and run along the southern face of Mara Hill, near the line of the wagon-road which leads from Tranquille to the ferry at Kamloops. These beds, representing an important interval in which volcanic materials were being laid down in the waters of the lake, have been named the *Tranquille beds.* Tranquille beds. Tuffs and agglomerates.

In the stratified materials of this subdivision, small collections of plants have been made from the lower part of Tranquille River by Mr. A. Bowman, and from corresponding beds on the south side of Kamloops Lake (those at the east end of Section No. 5a.,) by the writer. In these the following have been recognized by Sir J. Wm. Dawson. * Fossils plants.

Pinus trunculus, Dn.

Taxodium distichum, Heer.

Ailanthophyllum incertum, Dn.

Comptonia Columbiana, Dn.

Salix Kamloopsiana, Dn.

Ulmus like *U. Braunii*, Heer.

Sequoia, Sp.

Imperfect remains of fishes have also been found in these beds in this vicinity.

(6.) Overlying the last, and apparently not separated from that division of the section by any distinct line, is a great thickness of materials predominantly basaltic, consisting of brownish, blackish, gray and reddish basaltic agglomerates with occasional basaltic flows, which are, however, rarely columnar. The bedding of this series is rather massive and irregular, and the component beds are often lenticular, though from a distance the aggregate presents the appearance Basalts and basaltic agglomerates.

*Trans. Royal Soc. Can., vol. VIII., sect. IV., p. 75.

of a regularly stratified formation. The upper part, which is here the highest member of the Tertiary, shows a preponderance of rather soft, yellowish-gray agglomerates of a tuffaceous character. The component fragments though often vesicular, are frequently dense black trachytic material with the fracture of obsidian. The observed thickness of this highest member of the series is here about 2000 to 2500 feet.

Thickness.

The entire thickness of Tertiary beds displayed in this vicinity, may thus be stated at about 4800 feet.

Distribution of lower subdivisions.

Having described the section in this typical locality in some detail, it will now be in order to endeavour to trace the occurrence of its various members throughout the county in the vicinity of Kamloops Lake. For this purpose the local stratified intercalation designated as No. 3, may be disregarded, and the dolerites, forming numbers 2 and 4, may be considered as a unit. These rocks run round to the north of the central Battle Bluff mass for some miles to the westward, and were in some places observed to become concretionary in structure. They were not found at the western end of the older central mass, where the next overlying and bedded series (No. 5) seems to overlap directly on the rocks of the Nicola formation (p. 158 B) which are here attached to the Battle Bluff rocks and may be considered structurally as forming a part of that older mass.

How represented at Copper Creek.

Still further west, beyond a wide syncline occupied by the rocks of subdivision No. 6, the older members of the Tertiary series again reach the surface near Copper Creek. The dolerites appear here to be represented by igneous rocks rich in olivine, of the character of picrite-porphyrites and by augite-porphyrites, which so far as can be ascertained immediately overlie the cherty conglomerates previously described, and intervene between them and certain bedded materials, which are believed to represent No. 5 of the typical section, with a thickness of possibly about 600 feet. One of the olivine bearing rocks, where comparatively unaltered, has been determined by Mr. Ferrier to be an augite-picrite-porphyrite.* These rocks, together with the overlying bedded materials largely derived from their waste, have, in the vicinity of Copper Creek, suffered a remarkable amount of decomposition and change due to solfataric or hydrothermal action operating from below, and probably connected with the excessive faulting and fracture met with at this place.

Painted Bluffs.

The Painted Bluffs, on the east side of Copper Creek, are composed of these much decomposed rocks, apparently including parts of the

*Appendix I., No. 67.

overlying bedded series No. 5. Green, yellow and red colours prevail in the sloping and clay-like banks of rotten rock, amongst which rounded masses, and irregular layers of the undecomposed trap still exist. The olivine has become in many instances completely changed to serpentine in the decayed rock, while the felspars are more or less completely kaolinized. The whole section is traversed by dykes and by many small veins and seams of calcite.

Near the mouth of Copper Creek, on the lake, portions of the beach are largely composed of green sands, consisting for the most part of more or less worn small crystals of pyroxene. The nature of the alteration suffered by the olivine rocks at this place is fully described by Dr. B. J. Harrington in the Report of the Geological Survey for 1877-78, p. 41 G. The occurrence of cinnabar and of copper in connection with these rocks in this vicinity is elsewhere noted. Mineral occurrences.

A reddish brecciated rock, with greenish markings and cavities and well developed green hornblende crystals, which appears to lie near the base of the section above described, close to Copper Creek, was, it is believed again recognized on the lower part of Cherry Bluff Creek, on the opposite side of the lake, adjacent to the Cherry Bluff rocks and dipping off them. Some serpentinous and olivine-bearing rocks were also seen in the valley of this stream, and it is probable that rocks representing the part of the section now under discussion occur here, possibly in some force, but no good exposures of them have been found. Cherry Bluff Creek.

Opposite the typical section of the Miocene Tertiary rocks first described, on the south side of Kamloops Lake and to the east of Cherry Bluff, dolerites referable to No. 4, and possibly in part to No. 2, are seen in several places along the shore (Sec. No. 5a.). They also run round behind the rocks of Cherry Bluff more or less continuously, and at one place, a short distance south of the word "Bluff," as engraved on the map, are so coarsely crystalline and massive as to suggest the idea that they represent the place of an actual source of emission. Rocks east of Cherry Bluff

The stratified tuffaceous sandstones designated as the Tranquille beds (No. 5) probably run continuously round behind the Battle Bluff rocks on the north, following a hollow along the base of the higher cliffs and hills further back. They reappear on the lake shore near Red Point, with a breadth of about a mile; being thrown into a couple of light synclines and traversed at Red Point itself by a small fault. At this place, or very near it, a small bed of lignite was found during the progress of the Government railway surveys in 1878. The sandstones are here yellowish and gray, like those near the Tranquille. Distribution of Tranquille beds.

Their further outcrop is concealed by the lake, till they reappear in the Painted Bluffs near Copper Creek, where, as already explained, they are much altered and generally reddened.

East of Cherry Bluff.

To the east of Cherry Bluff, the same tuffaceous sandstones are found in several places, associated with the dolerites already alluded to, but the section (No. 5a) is here so much broken that it has been found impossible to satisfactorily unravel it with the information available. The widest and least disturbed exposures of these sandstones and shales here met with, are near mile-post 244 on the railway, where they dip northward at an angle of about 20°, and where a few fossil plants were found. It is believed that these beds run from this place inland, in an easterly direction, following the hollow along the south base of Dufferin Hill, and that they connect with those of the coal locality near Guerin's, where they terminate in a feather edge upon the underlying old rocks, at a point about three miles due south of the town of Kamloops.

Coal-bearing rocks south of Kamloops.

The exposures are not continuous along the line of outcrop thus traced, but there can be little doubt that the beds associated with the coal at Guerin's represent the Tranquille beds (No. 5) of the general section. These particular beds, where found near Guerin's, require special mention, because of the interest consequent on the discovery of coal in them, and the fact that some exploratory work has been carried out in the search for workable seams. The beds containing the coal here rest directly upon the pre-Tertiary surface, by overlap, the underlying members of the Tertiary being absent. The floor consists of a rough surface of diabase-agglomerates, upon which the Tertiary materials lie in the form of a shallow syncline which runs along the northward slope of Coal Hill. The exposures are almost entirely confined to the banks and bed of the small stream which flows past Guerin's house, and even with the aid of information obtained in the course of driving an adit into the measures, give but an imperfect idea of the section. The actual area of this projecting tongue of the Tertiary is shown on the map as closely as the facts observable on the ground admit. Its width is somewhat less than a mile—probably not more than three-quarters of a mile, while the thickness of the measures comprised in the syncline may be as great as 500 feet, but is possibly much less. The beds actually associated with the coal outcrops which have been uncovered, dip N. 25° W. $<$ 38°, but probably flatten out to the northward and take the position shown in the annexed section. The measures, so far as exposed, consist of greenish and yellowish tuffaceous and agglomerate-like materials more or less distinctly bedded, which weather to soft clayey

stuff, often reddish in colour. There are several thin layers of good coal, varying from mere films up to a foot in thickness, and characterizing in all about fifty feet thick of the measures.

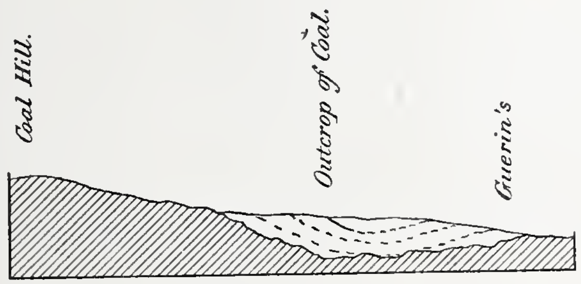

Fig. 2. SECTION INCLUDING COAL, NEAR KAMLOOPS.

The line of section is about north-east and south-west, passing through Guerin's house. The Miocene beds containing coal (division No. 5) are shown overlying rocks of the Nicola formation, indicated by the oblique parallel lines. Scale 2 m. = 1 inch.

The beds with which the coal is associated, undoubtedly pass under the basaltic agglomerates composing Mount Dufferin, to the northward, and if the coal should be found to occur there in workable thickness, this would prove a more eligible field for exploration than that to the southward of Guerin's, even if the coal beds of the last-mentioned locality were much thicker than any yet developed. Extent of these beds containing coal.

In 1892, the locality of the coal occurrence near Guerin's was again visited by Mr. J. McEvoy. At this time an incline was being sunk on the dip of the beds, which eventually reached a depth of from seventy to eighty feet, but without showing any marked improvement in the character of the seams.

The section including the coals, as then seen, was as follows, in descending order* :— Section.

	Inches.
Coal	3
Shale	5
Coal	12
Clay	4
Coal	2
Shale	6
Coal	3
Shale and clay	5
Coal	5
Shale and sandstone	12
Coal	2½
Sandstone	8
Coal	3

* From Summary Report of the Geological Survey for 1892, p. 10.

The quantity of clay is variable and some of the shale partings are not continuous. The aggregate thickness of coal at this place is $30\frac{1}{2}$ inches.

Further tests required.

The fuel found here is a true coal rather than a lignite, burning well and producing a coherent coke. If in seams of really workable thickness, it would possess considerable economic importance. To ascertain definitely whether any thicker seams occur at the locality near Guerin's, it would be necessary to sink or bore vertically through the measures, near the position of the present openings, till the subjacent diabase rocks are reached. The depth required cannot be great. Little further information can be hoped for in following the thin seams already found.

Places recommended for boring.

The whole area of possibly coal-bearing rocks in this vicinity is, however, so small, that it would appear to be better worth while to test the general question of the occurrence of coal in this neighbourhood by putting down one or more borings in places where the same subdivision of the Tertiary series has a greater development. The sites which seem to be most promising for this purpose with our present knowledge of the structure, are the following:—

Near the 244th mile-post on the line of railway or within half a mile east of that point on the line.

Tranquille River, on the east side, in the flat near the point at which the irrigation ditch is taken off and just below the mouth of the narrow cañon-like part of the valley.

A third locality might be selected about two miles east of the Tranquille River between the wagon-road and the base of the steep hill above it.

If no good seam of coal should be found in any of these places, it would be pretty conclusively proved that none exists in this vicinity, if, on the contrary, such a seam were discovered, the question might arise of tracing its extent elsewhere in the neighbourhood of Kamloops Lake, where further suitable sites for boring could be determined with the aid of the section which accompanies this report.

The occurrence, near Drooping-water Creek, of beds probably of the same age with those holding the coal at Kamloops, is described on a later page (p. 234 B). There also small quantities of coaly matter, with fossil leaves, have been observed. The two areas of deposit were, however, probably isolated, as the basalts of the intermediate country appear to rest directly upon the granites.

Fig. 3. PART OF THE NORTH SIDE OF KAMLOOPS LAKE, SKETCHED FROM THE MOUTH OF CHERRY BLUFF CREEK.

The parts vertically ruled consist of the plutonic rocks of the Battle Bluff mass, with, to the west, an attached area of Nicola rocks. The higher hills behind, consist chiefly of the basaltic member (No. 6) of the Miocene, forming an escarpment. Apparent dips from the point of view chosen, are indicated by the inclination and length of the arrows.

Escarpment of subdivision 6.

The highest of the Tertiary series in the vicinity of Kamloops Lake, described as No. 6 in the general section, has a notable effect in giving form to the topography of the district. It consists in the main of rough basaltic agglomerates and basalt flows, which have a tendency to form steep, rugged cliffs where the outcropping edges are worn away. A remarkable and continuous range of high, bold cliffs and escarpments, encircles to the north the lower hilly country occupied by the Battle Bluff rocks and the lower members of the Tertiary. This runs, with a curving sweep, from the vicinity of the Tranquille River to that of Red Point and then up the valley of Copper Creek. Similar escarpments occur along the main valley of the Tranquille, on both sides, at least as far up as the position of the waterfall shown on the map. The upper parts of Mara and Opax hills are formed of rocks of the same series, which are again well shown to the south of the lake, in Dufferin Hill.

Section in Savona Mountain.

Elsewhere to the south of the lake, these higher rocks have apparently been almost entirely removed by denudation, except in Savona Mountain. The summit of this mountain stands about 3700 feet above the level of the lake. It was ascended on the north side, and notes obtained upon which the annexed section is based. The lower and upper limit of each stratum could not in all cases be ascertained in such a manner as to enable its precise thickness to be stated, and the beds themselves evidently vary much in this respect in short distances, so that the section must be considered as more or less diagrammatic, although giving a sufficiently correct idea of the general

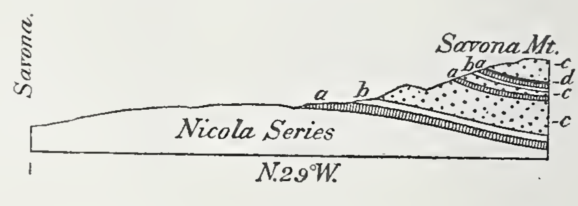

Fig. 4. SECTION FROM SAVONA STATION TO THE SUMMIT OF SAVONA MOUNTAIN.

Miocene volcanic rocks overlying those of the Nicola formation. Letters refer to the description in the text. Scale, 2 m. = 1 inch.

Character of rocks.

sequence. The lowest bed (*a.*) which apparently rests on the pre-Tertiary floor of diabases, felsites, etc., of the Nicola formation, is a gray somewhat vesicular basalt. This forms a distinct escarpment of 200 or 300 feet in height. Overlying this is a gray laminated trachyte (*b*) containing some small mica crystals, of which the thickness was not

ascertained. This is succeeded by a great thickness of volcanic breccia or agglomerate (*c*), including near its summit, on the line of traverse, at least one bed of brownish, more or less distinctly laminated basalt (*a*), The great agglomerate bed is followed in order by comparatively thin beds of trachyte (*b*), vesicular basalt (*a*), and a gray, obsidian-like rock (*d*). The trachyte has been determined by Mr. Ferrier to be a mica-trachyte with a tendency toward andesite.* The obsidian-like layer has a thickness of about 100 feet. Above these, the summit of the mountain is composed of a second great agglomerate (*c*), with a thickness of nearly 1000 feet.

The fragments composing both agglomerates are generally large, and their material differs much in character, but so far as observed consists entirely either of igneous rocks referable to the Tertiary or of the diabase-like rocks of the older Nicola formation. The upper agglomerate holds masses as much as six feet in diameter, which are generally somewhat rounded, but not more so than may be accounted for by friction in the vent from which they must have been expelled. The matrix is a gray tuffaceous material often resembling mortar. This agglomerate forms cliffs near the summit of the mountain, tending to wear out into pinnacles, each capped by one of the larger fragments which has served as a protection from the action of the weather. The basalts in some places hold numerous agates, which are often green or greenish in colour and sometimes very handsomely marked. Coarse agglomerates.

The entire series of beds included in the Savona Mountain section may be referred to No. 6, of the general section. Their aggregate thickness is about 3000 feet. The great size of a large proportion of the fragments here, together with the thickness of the agglomerates, appears to indicate the immediate vicinity of some local centre of eruption. The same beds seen on the north side of Savona Mountain, are continued southward along the west side of Three-mile Creek, where they form bold and picturesque cliffs. Thickness.

Recapitulating the general section of rocks about Kamloops Lake, and giving to each member its probable maximum thickness, the following scheme may be presented. It will, of course, be understood that the several subdivisions vary much in thickness, and are moreover not all present in any single place. The order is descending.— Recapitulation of Kamloops Lake section.

	Feet.
No. 6. Agglomerates, chiefly basaltic, with some basaltic and trachytic flows; all rudely bedded. Thickness in Savona Mountain..................................	3,000

* Appendix I., No. 68.

	Feet.
No. 5. Tranquille beds; tuffaceous sandstones and shales, with some soft tuffaceous agglomerates, all more or less distinctly water-bedded; holding occasional plant remains, fragments of fishes, carbonaceous matter and in some places coal. Thickness near Tranquille River, about	1,000
No. 4. Doleritic rocks, representing flows of molten matter. Thickness near Tranquille River about	1,000
No. 3. Tuffaceous shaly beds, generally in thin layers, holding obscure plant and fish remains. Local thickness near east end of Battle Bluff	200
No. 2. Dolerite, like No. 4. Thickness near east end of Battle Bluff, at least,	100
No. 1. Coldwater group; conglomerates composed of pre-Tertiary material, with some sandstones. Very irregularly developed and often wanting. Probable thickness near Copper Creek about	1,000
	6,300

Diagrammatic Section No. 5.

The section (No. 5) in which an endeavour is made to show the general features along the north shore of Kamloops Lake, after the details above given, scarcely requires further explanation. The synclinal form which the old rocks below the Tertiary are represented as holding at the west end of the section, is to some extent conjectural, as it is scarcely possible to determine the attitude of these beds here. It is based in part on observations made between Deadman River and Copper Creek, at some distance back from the lake, in part on the fact that a limestone, assumed to be the same with that seen on the lower part of the Deadman, must outcrop near the western edge of the Tertiary conglomerates here. This is rendered evident by the notable abundance of limestone in some of the Tertiary conglomerates or breccias at this place. It is further confirmed by the occurrence of limestone approximately on the presumed line of strike on the opposite side of the lake. That part of the section of Tertiary rocks to the west of Copper Creek, must be regarded as scarcely more than diagrammatic. Just east of Copper Creek, on the lake shore, a low hill occurs composed of a crushed granitic rock, which in common with the neighbouring Tertiary rocks, is excessively decomposed. It shows in places minute specks of cinnabar. It is uncertain whether this is an original projecting boss of the pre-Tertiary floor, or whether its appearance at the surface is partly due to faulting; but it is noteworthy that a couple of similar isolated granitic masses occur some miles to the north-westward of the lake in the continuation of the general line of the Copper

Boss of crushed granite.

Creek Valley. The main direction of faulting probably runs parallel to this valley.

Fault at Red Point.

The fault shown at Red Point, is very distinctly seen on the lake shore there, but its throw is in all probability quite small. It is interesting, however, in illustrating the manner in which the Tertiary beds are occasionally, and very locally turned up at high angles. The very high dips frequently found in the conglomerates to the west of Copper Creek, are supposed to have been produced for the most part in a similar manner, though as elsewhere explained, there is reason to believe that these conglomerates are considerably older than, and lie unconformably below the other Tertiary rocks (p. 69 B).

Other data embodied in section.

The overlap of the stratified rocks of the Tranquille series (No. 5) upon the pre-Tertiary surface, shown to the east of Red Point, depends on the examination of the line of junction nearly a mile back from the shore of the lake. On the shore, this part of the section was not closely examined.

As the upper line of the section is drawn at the water-level of the lake, it does not indicate the connected escarpment formed in the higher hills inland, by the rocks of No. 6, between Red Point and the Tranquille River. This is, however, one of the most prominent features of the north shore of the lake as seen from a distance. To the east of the Tranquille, the same rocks form the high plateau-like top of Mara Hill, and rest there upon the nearly horizontal beds of No. 5.

The intrusive dykes as represented near the east end of Battle Bluff, are not accurately laid down, but are intended merely to indicate the abundance of such dykes.

Section 5a.

It has already been explained that the section furnished by the south shore of the lake is very imperfect, particularly to the west of Cherry Bluff Creek. To the east of the massive rocks of Cherry Bluff, the exposures are much better, but they are complicated by a number of small faults, which appear to throw the strata down to the westward. The partial section (No. 5a.) given for this part of the south shore, will serve to indicate its general character, but in a diagrammatic way, as the positions and number of faults are very imperfectly known. In this part of the section, a total downthrow to the westward of about 1000 feet may easily occur. The basaltic rocks shown as coming in at the east end, are the lower parts of those which form Dufferin Hill, which is situated about three miles to the westward of the town of Kamloops.

Section of Tertiary Rocks along the Nicola Valley.

Nicola Section, No. 7. Data employed.

After the sections about Kamloops Lake, the most instructive general section so far obtained is that along the Nicola River. In 1877, a paced survey was made along the Nicola Valley, from the mouth of the river as far up as the confluence of the Coldwater, a distance of about forty miles. This examination was undertaken for the purpose of obtaining a section of the Tertiary rocks exposed along the valley, and with reference particularly to the extent and mode of occurrence of the coal deposits which had for a number of years been known to exist near the mouth of the Coldwater. It was conducted chiefly along the wagon-road which follows the valley, and allusion is made to the result obtained in the report for 1877-78 (pp. 127 B, 128 B). As a whole this result was disappointing, for the information gathered proved to be insufficient for the explanation of the section. When a re-examination of this part of the country was undertaken in 1888 and 1889, additional facts were sought for along the Nicola Valley, and in its vicinity on both sides. These have now been added to those previously obtained, and a careful reconsideration of the whole has been instituted, from which the section appended to this report results. (Section No. 7.)

Degree of accuracy obtained.

While this is believed to be at least approximately correct in its main features, it must be stated that the explanation given of many of the observed facts in detail on the section, is still more or less hypothetical. The probable existence of undetected faults of small throw, is the most important element of uncertainty, but the massive character of the beds and the general absence of clearly recognizable horizons of a continuous character, render it very difficult to prove faulting even where it is suspected. It would undoubtedly be possible, by the expenditure of sufficient time and the extension of surveys to a belt of country several miles wide on both sides of this part of the Nicola, to produce a section accurate in all its details. The section here offered is, however, sufficient to indicate the general attitude of the rocks in a broad way, and will be found of value in connection with the question of the possible extension of the coal-bearing rocks (Coldwater group) which occur at the surface near the confluence of the Nicola and Coldwater and at Guichon Creek.

General features.

Omitting from consideration here, the sandstones and shales of the coal-bearing locality just alluded to, respecting which some remarks are made on a later page, the composition and general structural features of the Tertiary rocks in the vicinity of that part of the Nicola included in the Kamloops sheet, are sufficiently clear. The series may here be described as consisting of two great divisions

separated by a horizon characterized by certain pale-coloured, often soft and frequently well-bedded tuffaceous materials. These are believed to correspond with the very similar beds on Kamloops Lake, to which the name Tranquille beds has been applied, and the same name is in consequence extended to them. This horizon, which appears to be continuously represented throughout the length of the section, has been employed as the principal clue to its intricacies. Beneath it is a great thickness of volcanic rocks, chiefly to be classed as porphyrites. These are sometimes distinct augite-porphyrites, of fresh appearance in regard to their mineral constitutents, but are often so much decomposed that, though the porphyritic structure is usually preserved, it is difficult to name them with precision. Above the Tranquille beds is another great mass of volcanic rocks, consisting generally of basaltic materials.

Tranquille beds.

The volcanic rocks of both the upper and lower parts of the series are sometimes clearly effusive, but perhaps more frequently fragmental, constituting agglomerates or volcanic breccias, and the rock species of the two parts of the series are not altogether mutually exclusive, so that no strict line of lithological division can be drawn between them.

Upper and lower divisions.

In regard to the general structural features, the Tertiary series as a whole is bounded to the north-east, in this region, by a line which appears to be that of a continuous fault, with downthrow on its south-west side. This follows the edge of the great granite mass on that side. The line of faulting runs about N. 35° W., by S. 35° E., and along it, beds of tuffaceous sandstones and other water-bedded volcanic materials are found in several places. These are believed to underlie the porphyrite rocks and to be quite distinct from the Tranquille beds above alluded to, although denoted by the same colour on the map. The lowest rocks seen near the mouth of the Nicola seem to be at about this horizon.

Great fault to north-east.

At or near the fault, the Tertiary rocks are often found inclined at high angles, or even vertical, but the series as a whole, in this region, has a low south-westward dip, upon which are superimposed a number of small transverse undulations. In the main, the Nicola Valley follows a line parallel to that of the fault, at an average distance of about three miles and a half from it. This line is approximately that of the outcrop of the Tranquille beds, and the position of the river may be traced to the existence of these softer and more easily eroded materials. In detail, however, the undulations just alluded to throw the line of outcrop of these beds into a series of zigzags, which cross and recross the actual line of the river. The beds themselves show

Relation of Nicola Valley to Tranquille beds.

a tendency to pass into tuffaceous agglomerates of a more or less earthy character, and in which it is often scarcely possible to make out any stratification. It is thus generally difficult to ascertain their thickness, even when the sections are good. To the south-west of this part of the Nicola Valley, is a wide syncline, occupied chiefly by the basaltic rocks of various kinds which overlie the Tranquille beds. These rocks form the Nicoamen Plateau of the map.

General composition of series.

Thus, so far as the composition of the Tertiary series in this region has been determined, it is made up as follows, in descending order :—

	Feet.
Basalts, basalt breccias, etc. (about)	3,100
Bedded tuffs (Tranquille beds) (")±	500
Porphyrites, etc. (about)	5,300
Total	8,900

Subdivision of Section No. 7.

In the following more detailed descriptive notes on the Tertiary rocks found along the valley of the Nicola, the section is divided into five parts, each of which follows one of the minor trends of the valley, and though the section may be described as a whole, as running from north-west to south-east, it has been found convenient to change the direction in each case to correspond with that of the general bearing of a certain length of the valley. On the annexed diagrammatic section, these changes in direction are clearly indicated.

Part 1.

Part 1.—This extends from the mouth of the river in a direction S. 40° E., to a point one-half mile above the confluence of the first small stream from the north-east, with a total length of about six miles.

Oldest rocks.

The lowest rock met with, is that seen less than a quarter of a mile above the bridge by which the wagon-road crosses. It is a gray amygdaloidal material of a rather soft tuffaceous character, apparently nearly flat, and very probably forming the summit of a gentle anticlinal swell. Beyond this, in ascending the valley, most of the beds comprised in this part of the general section have southerly dips at angles of 30° or less. The valley crosses the outcrops obliquely, and the series is in the main an ascending one. From this general rule there are, however, two exceptions. At about two miles up the river, the beds are found to flatten out and to run nearly horizontally for about a mile further. Again, for nearly a mile at the end of this length of the section, the beds become undulating and are in the main not far from horizontal.

Newer rocks in ascending valley.

The general effect of the attitude of the beds is, however, that newer strata are found in order in ascending the valley, and the whole thickness thus exposed, to the base of the Tranquille beds, which form

the highest member here seen, is about 5300 feet. Of this the lower part, some 3100 feet, consists, so far as seen, of reddish, blackish and greenish volcanic rocks, often brecciated, occasionally vesicular, and in general to be classed as porphyrites of various kinds. An important bed of greenish, somewhat earthy, tuffaceous agglomerate or volcanic breccia then appears, which, with various volcanic rocks of green, gray-green and dark colours constitutes the next 2200 feet in thickness of the section. As before, these rocks are in the main porphyrites. These are followed in ascending order by well bedded tuffs or tuffaceous sandstones, apparently entirely composed of fine-grained volcanic materials, which have been arranged in regular layers of water. No complete display of this member of the section was seen, but it was noted to be at least 130 feet in thickness, and it may very considerably exceed this. These stratified tuffs are referred to the horizon of the Tranquille beds.

Part 2.—This connects with the last, and runs in a direction of S. 30° E. to the mouth of Skuh'-un Creek, a distance of exactly six miles. It is the least satisfactory part of the entire section, inasmuch as the main direction of the dip of the beds is south-westward, and the line of section consequently nearly follows the general strike. It is further complicated, near the mouth of Skuh'-un Creek, by several rather pronounced subsidiary flexures and possibly by some faulting. This part of the section can thus only be regarded as a connecting link, in which the beds are shown to lie in a position approximately correct. In the main, the river coincides with the outcrop of the Tranquille beds, crossing and recrossing it. The line upon which this part of the section is projected, lies a little to the north-east of the corresponding length of the river, and consequently to the eastward and stratigraphically below the greater part of the sinuous outcrop of these beds, which are more persistently represented along the river itself than the section indicates.

Part 2.

Outcrop of Tranquille beds.

No great thickness of rocks is clearly seen in this length of the section, but here, as in the first part, the material immediately underlying the Tranquille beds is a hard greenish or green-gray porphyrite. The water-bedded materials are greenish, pale gray and brownish in colour and generally fine-grained, but they pass in places into greenish tuffaceous breccias of earthy fracture, which do not show any distinct evidence of deposition in water. In one place, a mile and a half below Skuh'-un Creek, the well bedded materials were observed to be directly overlain by a blackish obsidian-like rock, probably a fine-grained augite-porphyrite.

Porphyrites.

Basalts.

The highest dips, observed locally, are at angles of 20° to 30°, while considerable parts of the formation appear to be nearly horizontal. The mountains along the south-west side of the valley seem to be almost entirely composed of massive basalts and basalt-breccias, with a general low westerly dip, but showing some light transverse undulations in their outcrops.

In the part of this section nearest to Skuh'-un Creek, beyond the last outcrop of tuffaceous sandstones in that direction, the attitude given to the beds is little more than conjectural, having been made to agree with the adjacent end of the next length of the section. A considerable thickness of the lower part of the formation must either come to the surface in the way indicated, or a corresponding change of horizon must be produced by faulting, with a downthrow to the north-westward, of which no direct evidence was observed.

Part 3.

Part 3.—This extends from the mouth of Skuh'-un Creek to the vicinity of that of Smith's Creek (the next small stream from the north-east) in a bearing of S. 43° E., and is about four miles and a half in length. Comparatively little is seen of the rocks near the wagon-road, which run for the most part along terraces at some distance from the river, in this part of the valley. The rocks are, however, almost continuously exposed along the river itself, and were somewhat carefully examined on the south-west side of the river. From a point about three-quarters of a mile above the mouth of Skuh'-un Creek, the section appears to be, for two miles and a half, continuously an ascending one, with south-easterly dips averaging perhaps 30° and sometimes rising to 40°. A better idea of the constitution of the Tertiary volcanic series was gained here than elsewhere in the valley.

Rocks chiefly porphyrites.

The rocks consist for the most part of porphyrites, probably all originally augite-porphyrites, but often much decomposed. It is perhaps impossible to draw very definite lines between the different component strata in all cases, even if the information available were much more detailed than it is, but the general character of the materials may be indicated as follows, in ascending order.

Series in ascending order.

The lowest beds seen, appear, as already stated, to be those at about three-quarters of a mile above the mouth of the Skuh'-un, where an anticlinal axis is supposed to cross the Nicola. These are gray-green porphyrites and greenish-gray porphyritic agglomerates, of which the felspathic constituents are almost entirely decomposed, giving the rocks a dull speckled appearance, and in some of which newer crystals of zeolitic minerals have been developed. These are followed by dark

greenish, bluish and dull purplish porphyrites, the latter preponderating, generally much fresher and with clearly defined felspar crystals.* Above these, just below the mouth of a small stream which enters from the south-west, is a gray augite-porphyrite, with a foliated appearance, due to lines of flow-structure in its mass.† Next in order is a red, rusty, shattered felspathic rock, now scarcely determinable, followed by a dark greenish-black porphyrite in which some fragments of coarse gray gabbro were observed to have been caught up. This is succeeded in turn by much decomposed purplish porphyrite,‡ grayish porphyrite, reddish porphyrite-agglomorate and dark greenish-gray, fine-grained, much decomposed porphyrite with flow-structure.

Next in order are the Tranquille beds, which here form a syncline near the south-eastern end of this part of the section. They consist, in great part, of well-stratified, fine-grained rocks of gray and yellowish-gray colours, usually pale and sometimes much indurated, resembling felsites; but also pass into coarse clastic and agglomorate-like tuffs, between which and the finer and more regularly bedded materials it is often difficult to draw any precise line. In the centre of the syncline and overlying these water-laid materials dark brownish basalts are found.

Tranquille beds agglomeritic.

The rocks comprised in this part of the section, below the Tranquille beds, evidently represent those holding a similar position in the first part of the section, near the mouth of the Nicola, but differ somewhat from them in lithological character. The greenish and gray pale-coloured tuffaceous agglomerates there seen, are not here represented to anything like the same extent, being replaced by more compact porphyrite. Taking the observed attitudes and measurement of the section of this place, the probable exposed thickness of the strata below the Tranquille beds, is again about 5300 feet, while the minimum possible thickness, according to the observations made, is 3700 feet. The thickness of the Tranquille beds and associated tuffaceous materials appears to be something like 800 feet, being considerably greater than in the lower part of the valley. The porphyrites composing the entire lower division of this part of the section are usually hard, and some of them, apart from their association, might easily be mistaken for rocks of parts of the much older Nicola formation. They generally, however, weather to brown colours, in a manner somewhat different from the typical rocks of that formation.

Volume of rocks exposed.

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* Appendix I., No. 62. †Appendix I., No. 55. ‡Appendix I., No. 61.

Rocks seen near Skuh'-un Creek.

The sequence and arrangement of the Tertiary volcanic rocks away from the actual valley of the Nicola, on either side, have not been examined into in detail; but in this vicinity, along the route shown on the map following the north branch of Skuh'-un Creek towards the Pimainus Lakes, it was found, that the lower part of the section above described is repeated, with southerly or south-westerly dips, the lowest beds being next to the faulted contact of the Tertiary with the granites. This repetition occurs in a length of about three miles, measured along the route indicated, from the edge of the granites. In immediate contact with the granites, along the line of fault, some earthy, fine-grained, tuffaceous agglomerates of pale greenish colour are found, which do not appear in the anticlinal near the mouth of Skuh'-un Creek, and are lower than any of the beds seen there. These probably represent the first rocks noted at the mouth of the Nicola River, and though in some respects resembling the Tranquille beds, and apparently implying like these, some contemporaneous water action, they belong to a much lower horizon.

Part 4.

Part 4.—This extends from the end of the last, at the mouth of Smith's Creek, for a distance of four miles, in a bearing of S. 24° E. to the mouth of the next small stream from the north-east. As in Part 2, the valley here nearly follows the main line of strike, the general dip being as before in a south-westward direction. This part of the section, as represented, depends entirely on observations made in 1877, on and near the wagon-road. The rock exposures are few and poor toward both ends, but are good and nearly continuous for more than two miles. The Tranquille beds, as found in this part of the valley, consist to a greater degree than before of coarse, gray and brownish, tuffaceous or felspathic sandstones, in which fragments of carbonaceous matter were in several places observed. The very fine-grained gray, well-bedded tuffaceous rocks before so abundant, are, however, also present here, while a nearly white, fine-grained tuff also appears in considerable volume. All these materials form compact rocks. Near Pulpit Rock considerable exposures occur of rough brownish breccia, which is supposed to underlie the tuffaceous sandstones.

Carbonaceous matter in tuffs.

Part 5.

Part 5.—This continues the general section for a further distance of about four miles, to a point on the Nicola a little above the mouth of the Spioos River. The line of section here runs about S. 35° E. Only about a mile of this part of the section is actually included within the Kamloops sheet, but as the section met with in the Nicola Valley from the Spioos to the confluence of the Coldwater is not yet very well understood, while it appears to be moderately legible up to the mouth

of the Spioos, it is considered advisable to carry the description thus far. Just above the mouth of the Spioos, the lower part of the valley is occupied by a projecting mass of old rocks, consisting of green schistose materials, highly charged with pyrites and weathering rusty. These dip N. 15° E. < 50°. Between the north-west end of this part of the section and these old rocks, the Tertiary rocks form, so far as has been ascertained, a low synclinal flexure, of which the south-east side progressively overlaps the older projecting mass. The old rocks are confined to the lower part of the valley of the Nicola, where they have a breadth of perhaps half a mile. In the hill above, a brown porphyritic agglomerate covers them, so that but for the erosion of the Nicola River, they would not be seen. In the syncline just referred to, the Tranquille beds are believed to be represented by certain white, hard porphyrites, which appear to be in part bedded and tuffaceous. The reference is, however, made not without some doubt, and subject to future investigation. Where seen, these dip S. 35° E. < 25°. They were not observed on the south-east side of the syncline nearest to the old projecting mass. Some basaltic rocks appear in the centre of the syncline.

Projection of older rocks.

Tertiary Rocks to the South-west of the Nicola Valley.

The Tertiary rocks of the rough high country situated between the Nicola, the Thompson and the Nicoamen rivers, constituting the Nicoamen Plateau of the map, have been examined in 1888 and 1889 along a few lines only. The southernmost of the routes followed, leaves the Nicola about a mile beyond the south line of the map, and runs eastward to Za-kwaski Mountain and beyond, being throughout a short distance to the south of the present sheet. The next route, starting from the vicinity of Za-kwaski, runs north-eastward to the Nicola, midway between Skuh′-un and Smith's creeks. The third, crosses the plateau from the mouth of the Nicoamen River, reaching the Nicola a few miles above the mouth of the Skuh′-un. The last is the only one which can be described as following a travelled trail, the others being merely forced routes through country scarcely practicable for pack-animals.

Routes followed on Nicoamen Plateau.

Between the mouth of the Nicola and that of the Nicoamen, the Thompson River is bounded by Tertiary rocks on both sides, till, within about three miles above the Nicoamen its channel becomes nearly coincident with the line between these rocks on the east and the granitic rocks of the southern part of the Scarped Mountains on the west. About a mile and a half above Drynoch station, the railway track is laid

Thompson Valley.

across what is known as the Big Slide, a mass of soft débris, which is still in a gradual, if intermittent, state of motion towards the Thompson River. The material of the slide consists of yellowish and brownish soft tuffaceous deposits, completely poached together and packed with fragments of basaltic and other volcanic rocks. It has descended to its present position from a high level on the edge of the Nicoamen Plateau, where rocks of the same kind are still seen in place, and are supposed to represent a continuation of the Tranquille beds described on the Nicola. The outcrop of these beds probably crosses the northern part of the Nicoamen Plateau, but has not been definitely traced there. As viewed from high points on the other side of the Thompson, the Big Slide is found to have originated from the edge of a flat meadow-like area with little pools or lakes, which forms part of the edge of the Nicoamen Plateau here. Where crossed by the railway below, it consists of irregular mounds and ridges, with frequent gaping fissures, and is evidently slowly subsiding upon the inclined surface of hard underlying rocks, the evidences of motion being greatest at seasons when the soil is saturated with moisture.

Big Slide.

Near Drynoch.

Below Drynoch station, half-way between mile-posts 170 and 171 on the railway, a small intercalation of greenish tuffaceous rocks, which apparently dip north-eastward at high angles, was observed. This dip is, however, probably local, for between Drynoch and the mouth of the Nicoamen the Tertiary rocks appear to be very much disturbed, and it is often difficult to distinguish between those actually in place and broken portions of the formation which seem to have slipped down toward the great valley of the river. Much bright red, highly ferruginous basaltic material is seen, but seldom distinctly *in situ.*

Disturbed edge of Tertiary.

Where the line of the Thompson becomes practically coincident with that separating the volcanic rocks of the Tertiary on the east and the granites on the west, it is apparently accompanied by faulting or crushing of the margin of the Tertiary rocks, though the original condition seems to have been one of overlap of these rocks upon a steep border of the granites. In cutting down along this line, the river has detached a couple of small edges of the Tertiary, as indicated on the map, and one of these lies just opposite the mouth of the Nicoamen.

Nicoamen.

At Nicoamen, about 200 yards to the north of the bridge across that river, it was reported that coal had been found, and an examination was made of the locality indicated. Carbonaceous shales containing some small fragments of coal or lignite occur at this place. These shales are several feet in thickness, and are overlain by yellowish and greenish shales and shaley clays, apparently composed of tuffaceous

Lignite.

materials, and underlain by gray coarse sandstones containing a good deal of quartz and evidently derived in large part from the disintegration of the adjacent granites. It is reported that a bed of better lignite is visible near Nicoamen at very low stages of the river, but this was not seen.

Tranquille beds.

The water-bedded intercalation here met with, is believed to represent the horizon of the Tranquille beds, and it is probable that these beds might be traced along the hillside, gradually descending southward to this place, from the point previously mentioned at which the Big Slide has originated from them.

Tertiary edge west of Thompson.

The narrow margin of Tertiary rocks already noted as existing on the west side of the Thompson opposite Nicoamen, may here be referred to in passing. This appears to have a length of about a mile, and according to Mr. McEvoy's observations, the northern part consists of a brownish porphyrite, the southern part of gray arkose sandstones derived from the adjacent granite rocks, with some brown breccia, considerably decomposed. The horizon of the rocks last mentioned is probably about the same with that of the sandstones and shales at Nicoamen.

Basaltic series behind Nicoamen.

The rocks forming high cliffs at the fall of the Nicoamen, near its mouth, and seen in ascending the very steep hill on the trail to the north of the river, are chiefly vesicular and amygdaloidal basalts, weathering to red colours. These are believed to follow the sedimentary materials last described, in ascending order. Higher up, and further east, in following the trail across the plateau toward the Nicola, much basalt-breccia or agglomerate is seen. All these rocks preserve a marked lithological uniformity, and from the fall to the summit of the plateau, on the trail, are nearly horizontal, in so far as the attitude of such massive beds could be determined. The trail crosses the plateau at an elevation of about 2660 feet above that of the flat at the foot of the fall, while above the transverse valley along which the trail runs, hills of the same composition rise to a further height of about 500 feet. Thus, on the assumption that the sedimentary and carbonaceous beds near the mouth of the Nicoamen represent the Tranquille beds of the Nicola section, we have for the upper preponderantly basaltic member of the Tertiary in this region, a minimum thickness of about 3100 feet.

Agates.

The basaltic rocks in this part of the plateau are frequently amygdaloidal, the cavities containing numerous well banded but pale-coloured agates, with zeolites and green chloritic material.

Descent to Nicola Valley.

On reaching the steep slopes descending toward the Nicola Valley, the basaltic rocks are found to have a very general south-easterly dip, at an average angle of about 10°; and before getting down to the

river, on the line of route followed, bluish and purplish porphyrites appear, similar to the rocks of the same kind in the Nicola Valley which have already been described at length. It is probable that some rocks of this kind here overlie the Tranquille beds, but no distinct section including these beds was met with in descending to the Nicola River at this place.

Higher parts of Nicoamen Plateau.

The route first referred to at the beginning of this section of the report, and there described as running from a point on the Nicola about a mile beyond the edge of the map eastward to Za-kwaski, follows the highest parts of the plateau, consisting of ridges and uplands which separate the tributaries of Agate Creek and the Nicoamen River on the north from those of Prospect Creek, a tributary of the Spioos, on the south. A considerable part of the route thus followed is at an elevation of about 6000 feet. As already mentioned, it is everywhere to the south of the map-sheet, its greatest distance from this edge being in one place as much as four miles. Za-kwaski Mountain, the position of which is indicated on the map, lies at about a mile and a half to the south of the south line. The rocks observed on this route were entirely volcanic and chiefly basalts of somewhat varied colour and texture, often brecciated. No approach to a connected section was obtained, and it has not therefore been thought worth while to make any microscopical examination of the isolated specimens brought back. Chalcedony and agates, together with crystalline quartz, are rather notably abundant in amygdaloidal cavities in some of the rocks and small specimens of zeolitic minerals, including stilbite and heulandite, were also found.

Za-kwaski Mountain,

Za-kwaski itself is a block-shaped mass which stands on the south-east margin of this part of the Nicoamen Plateau, overlooking on that side a deep valley in which small branches of the Nicoamen and Prospect Creek head together. Beyond this valley are the granitic rocks of the Lytton Mountains. Though elevated about 450 feet only above neighbouring parts of the plateau, Za-kwaski is a prominent landmark and can be seen from many of the high points occupied by us in the south-western part of the Kamloops sheet. Its actual height is 6600 feet. It is easily climbed on the eastern side, and is composed throughout of a homogeneous, fine-grained, gray augite-porphyrite, which rings under the hammer.* A nearly horizontal foliation or flow-structure is present, with two systems of nearly vertical jointage planes, causing the rock to break out easily in quadrangular blocks,

Composition.

*Appendix I., No. 54.

with which the slopes are strewn. This rock is very different in appearance from the darker and more basic augite-porphyrites previously described. Macroscopically it resembles a trachyte. The thickness of the mass of which Za-kwaski is composed must be 500 feet or more, and it appears at this place to be the lowest representative of the Tertiary volcanic series, resting directly upon the granites, by overlap. Its precise relation to the Tertiary section as displayed along the Nicola is not known, but it may represent the horizon of the trachyte-like eruptions to which much of the material of the Tranquille beds is due, possibly here near a centre of eruption. A distant view of Za-kwaski from the northern part of Lytton Mountains showed its general relations to the granite and to the overlying basaltic members of the Tertiary volcanic series more closely than these could be observed on the ground itself.

Nicoamen Plateau near Agate Creek.

The second route, noted at the beginning of this section of the report as running from the vicinity of Za-kwaski north-eastward to the Nicola, will be found indicated on the map. It follows a high ridge to the east of Agate Creek, of which Mī-mēm-ooh, with a height of about 6000 feet is the culminating point. This point and the crest of the ridge for two miles or more in length in its vicinity, is composed of gray, generally pale-coloured rocks of trachytic appearance. All are apparently eruptives, and some are more or less amygdaloidal. The actual bare summit of Mī-mēm-ooh is composed of a hard but much decomposed porphyrite.* To the northward of this part of the ridge, basaltic rocks are characteristic, till in the immediate vicinity of the Nicola Valley, the Tranquille beds are found, forming the upper part of the section extending eastward from the mouth of Skuh'-un Creek, which has already been described in some detail (p. 181 B).

Disturbance of rocks.

The observations made on this and the foregoing line of traverse, together with what has been seen on Spioos River and its branch Prospect Creek (of which no description is included in the present report) lead to the belief that the Tertiary volcanic rocks of the south-eastern part of the Nicoamen Plateau are somewhat complicated by low undulations, of which the position and trend have not yet been fully ascertained.

Tertiary Outliers in the Lytton Mountains.

Three isolated patches of Tertiary rocks lying to the south-west of the Nicoamen Plateau, may be mentioned here.

*Appendix I., No. 59.

Patches of conglomerate and basalt.

At a height of about 4000 feet, on the north slope of Lytton Mountain, a small outlier of Tertiary conglomerate was discovered. This contains pebbles, and more or less perfectly rounded boulders of granites and of Tertiary volcanic rocks. It is probably a part of the deposit of some body of water which existed during the later stages of the Miocene period of volcanic activity. A little further south on the same mountains, a much larger outlier of grayish and reddish basaltic rocks occurs. This is evidently a portion of the former edge of the flows capping the adjacent Nicoamen Plateau. The dip of these rocks nearly follows the slope of the hill, being, where observed, about N. 50° E. < 15°.

Tertiary beds with lignite, near Fraser.

Another and in some respects a very remarkable outlier of rocks of Tertiary age, occurs near the Fraser, on the west side of the Lytton Mountains, just beyond the bordering line of the present map. This was examined by Mr. A. Bowman in 1885, according to whom it occupies a small flat area at a height of about 800 feet above the line of railway, with a greatest width of possibly as much as half a mile. The rocks found by Mr. Bowman are gray shales with some poorly preserved plant impressions, and small quantities of lignite were also seen by him. It is not known to what stage of the Tertiary this little patch of sedimentary rocks is attributable, but its very low elevation —about 1500 feet above sea-level only—is noteworthy, and for this region anomalous.

Tertiary Rocks to the North-east of the Nicola Valley.

East side Thompson River.

On the east side of the Thompson, above the mouth of the Nicola, the north-eastern edge of the Tertiary is found near the 184th mile-post on the line of railway. The rocks here seen, from the dips observed on both sides of the Thompson, are probably the lowest exposed in this vicinity, but it is believed that their actual junction with the older series to the north is accompanied by faulting, in continuation of the persistent line of fault already noted (p. 177 B). The rocks are grayish, greenish and pinkish-gray agglomerates, rather soft, with a somewhat earthy fracture, but largely composed of porphyritic débris. Nearly on the presumed line of strike of these rocks, on the west side of the river, some beds of tuffaceous sandstone are found, but these were not recognized in a corresponding position on the east side.

Tuffaceous beds.

Two miles further south, near the 182nd mile-post, about half a mile below the mouth of Pimainous Creek, on this (east) side of the river, a thickness of several hundred feet of well bedded tuffaceous materials is found. These dip about S. 60° W. < 20°, but the dip becomes less to

the south-westward. The same beds were observed on their line of strike on the opposite side of the Thompson, with similar dips. Lithologically they resemble the Tranquille beds of the Nicola Valley, but it is quite possible that they may represent a lower horizon. Their connection with the rocks of the Nicola Valley section has not been traced out and for the present must remain in doubt.

Fault and exposures in Pimainus Valley.

The line of faulting, which in general bounds the Tertiary volcanic rocks to the north-east of the Nicola, is believed to cross Pimainus Creek about a mile and a half above its mouth. Thence, for about five miles south-eastward in the Pimainus Valley, a selvage of the Tertiary volcanic beds, to the north-east of the fault, appears to lie directly upon the granites. For part of this distance along the valley, its south-west side consists of high cliffs and scarped hills, in which at least 1000 feet of beds is shown. These appear to lie nearly horizontal, and consist of a series of massive beds or layers of somewhat varied appearance, comprising agglomerates and augite-porphyrites of different kinds.* In the higher part of the hills vesicular basalts seem to preponderate, but no bedded tuffaceous materials were here met with, nor were any fragments of this kind or of ordinary sandstones found in the wash of the stream itself.

Skuh'-un Valley.

The Tertiary rocks seen to the north of Skuh'-un Creek and near to the edge of the granite in that vicinity, have already been described in connection with the Nicola section. In that part of the main valley of Skuh'-un Creek to the west of the granite area, porphyrites of different kinds were seen in several places, but no connected section was obtained. Near the granite edge, the abundance of loose fragments of greenish tuffaceous sandstones gives reason to believe that a rock of this kind outcrops, but it was not actually seen in place.

Smith's Creek.

Further to the south-eastward, the valley of Smith's Creek was ascended for the purpose of defining the position of the junction of the Tertiary rocks with the granites. The whole valley and its slopes are so deeply covered with drift materials that little was seen. There is a point on the stream, however, where the débris changes suddenly from an entirely granitic composition and begins to contain a larger proportion of Tertiary rocks, and near this point an exposure was found on the left bank, of hard, yellowish tuffaceous beds, apparently nearly on edge. These are believed to represent the lowest member of the Tertiary at this place and to be in immediate proximity to the line of fault.

Tuffaceous beds.

The next small stream entering the Nicola from the north-east, was also examined for a couple of miles, but without actually reaching the

* Appendix I., No. 56.

edge of the granite. White trachyte-like rocks, are here rather notably abundant,* but on microscopic examination they were found to be mica-porphyrites in composition.

Tertiary Rocks to the North of the Eastern Part of the Nicola.

Projecting points of Tertiary.

To the east of the point at which the Nicola enters the Kamloops sheet, the south line of the map cuts the physical and geographical features of the country in a somewhat unfortunate manner. From the lower end of Nicola Lake to the point above mentioned, the Nicola flows for a distance of over seventeen miles to the south of the map, but never at a greater distance than four miles from it. In this part of the valley coal-bearing Tertiary rocks are developed, but only two projecting points of the Tertiary actually extend within the limits of the map. One of these occupies the lower part of the wide tributary valley of Guichon Creek, the other runs up upon the plateau to the west of Clapperton Creek.

Nicola-Coldwater Coal-field.

Although thus beyond the limit of the present map, a few words may be inserted here on the coal-bearing strata found about the confluence of the Coldwater and Nicola Rivers. A description of these occurrences is given in my report for 1877-78 (pp. 122 B-126 B) but since that time borings made in the vicinity show that the coal-seams have an extent of at least several miles beneath the alluvial lands of the wide Nicola Valley, a matter which could only be one of inference in 1877. Subsequent investigations have likewise shown that the coal-bearing strata (constituting the Coldwater group of the present report) must be regarded as unconformable below the volcanic Tertiary strata, while they also indicate that the conjecture hazarded in the previous report as to their passage beneath Iron Mountain, is probably incorrect, inasmuch as it now appears to be probable that the mass of this mountain is composed of rocks of the Nicola formation.

Section in Coal Gully.

The best natural general section of the rocks is that found in Coal Gully, facing the Nicola Valley and about a mile and a half from the bank of the Coldwater. As given in the Report for 1877-78, it is as follows :—

	Feet.	In.
(1.) Soft yellowish sandstone, in thin beds, at the top of the hill	32	0
(2.) *Coal*, laminated, rather soft	15	4
(3.) Sandstone, rather soft, with some shale	89	0
(4.) *Coal*	5	4

* Appendix I., No. 46.

		Feet.	In.
(5.)	Sandstones with a considerable thickness of shaly beds at the base..........	141	0
(6.)	*Coal*.......................... ....(about)	3	0
(7.)	Sandstones, generally in thin beds...............	136	0
(8.)	*Coal*........ ....(about)	2	5
(9.)	Sandstones.....................................	[illegible]	..
		424	1

The two upper beds designated as coals, might be more correctly described as lignite-coals, and it is not certain that any of the coal-beds in this section corresponds with that which has been wrought from time to time in a small exposure on the bank of the Coldwater, which shows a thickness of at least 5 feet 3 inches of workable coal, of good quality and yielding a coherent coke. This is referred to as the "main seam" in the Report of 1877-78, which should be consulted.

Since the above was written, the results of two test borings made in the Nicola Valley in this vicinity by the Nicola Valley Company, in 1891 and 1893, have become available for publication. It would be inappropriate here to enter into details respecting the field, as it lies beyond the edge of the present map-sheet and requires further investigation, but it may be stated that a coal-seam undoubtedly representing the so-called "main seam" has been found in both borings. These borings were put down in accordance with my recommendation, in the flat part of the valley, which is entirely covered by alluvial deposits. The first (No. 5) was situated on Lot 123, Township 91; the second (No. 7) on the east side of the north-west quarter of section 14, both being in the angle between the Nicola and Coldwater rivers. The level of the surface at both places may be considered identical. Result of recent borings.

In No. 5, the part of the section supposed to represent the main seam is as follows:—

	Feet.	In.
Coal....	3	8
Sandstone......	0	6
Coal............	1	4
Sandstone..	0	8
Coal..	0	7
Total coal....................................	5	7

Depth of base of seam from surface, 196 feet 9 inches.

In No. 7, the corresponding portion of the section is as follows:—

	Feet.	In.
Coal	0	8
Shale	1	1
Coal	0	6
Slate	0	4
Coal	4	4
Total coal	5	6

Depth of base of seam from surface, 144 feet 5 inches.

No. 5 was carried down to a depth of 600 feet, and No. 7 to 563 feet, cutting, in each case, through several more thin seams not of workable dimensions.

The coal.

The coals obtained in these borings yield a good strong coke. The two borings are distant from each other about a mile and a half, and although the natural outcrops to the south of the line joining the borings show some stratigraphical complication, the result of these tests is to indicate that a considerable undisturbed and easily workable coal-field exists beneath the valley.

From the above short note on the Nicola-Coldwater coal-field proper, we may return to the northern arms of rocks of the same age which, as already stated, actually appear upon the map.

Rocks from end of section to Guichon Creek.

A mile and three-quarters eastward along the road from the projecting boss of old rocks which terminates the diagrammatic section along the Nicola, another similar projection of old rocks appears in the bottom of the valley, with a width on the road of about eight-tenths of a mile. The level of the river throughout this part of its length, is evidently not far from the local base of the Tertiary, but no underlying sedimentary deposits were actually seen here. At about two miles further eastward, within a mile of the bridge across Guichon Creek, a hill of whitish trachytic-like rock borders the road. This rock has a dull fracture, is in part an agglomerate and appears to be rudely bedded. It is believed to overlie directly the sedimentary deposits of the lower part of the Guichon Valley, next to be referred to.

Coldwater beds on Guichon Creek.

These sedimentary rocks have been noticed in my report of 1877 (p. 126 B), in connection with the coal-bearing beds seen near the mouth of the Coldwater. A further attempt has since been made to acquire more precise data respecting them, but with indifferent success, the whole of the low country which they occupy being more or less deeply drift-covered. The area actually held here by the Tertiary sedimentary rocks is, I believe, now defined with some approach to accuracy,

though, as represented on the map, the outlines are largely dependent on the contour of the surface, taken in connection with observed outcrops of the older rocks which in some places fix maximum limits.

Character of the strata.

The Tertiary rocks themselves, here consist of soft yellowish and pale gray shales and shaly sandstones, with some beds of rather earthy, whitish, arkose sandstone of medium grain, containing much sub-angular quartz, mingled with decomposed felspar, and evidently resulting chiefly from the disintegration of granite. These are seen, apparently in place, in some of the gullies on the east side of the valley, between the wagon-road and the base of the steeper hill, but there is so much evidence of old (probably pre-glacial) land slides, and the whole surface of these soft deposits has been so completely poached up during the glacial period, that it is very seldom possible to be sure that any of the beds are undisturbed. They are frequently incorporated in considerable quantity in the boulder-clay, which in consequence assumes yellowish tints locally.

Lignite and ironstone.

The broken shaly materials are found in several places, particularly in bluffs along the immediate valley of the stream, to hold fragments of lignite and of ironstone. The lignite was not anywhere seen in place, and although beds of lignite or coal have been reported here, it is probable that the reports depend merely on the occurrence of such fragments.

Probable relations of the beds

It is in the main, sufficiently clear, that the lower part of the Guichon Creek valley is floored with these Tertiary sedimentary deposits, which have been laid down when it formed an arm or inlet of the body of water in connection with which the coal-bearing strata of the vicinity of the mouth of the Coldwater were deposited. It is probable that the beds here seen at the surface, represent those of the higher part of the section near the mouth of the Coldwater, which they closely resemble lithologically, as well as in the association with them of lignite, instead of the coal found near the base of the formation at the Coldwater. It is further probable, that these higher beds here transgressively overlap the old rocks, for if their occurrence were due to a subsequent synclinal flexure, the upturned edges of the harder and more massive sandstones and conglomerates of the lower part of the formation, would almost inevitably have formed bold outcrops about the edges of the basin. Thus, if these lower beds are here present, it may be presumed that they occupy the deeper part of the original valley without coming to the surface. This would indicate that if a search is to be made here for the better fuels of the lower beds, it must be conducted by boring somewhere near the middle line

Site recommended for boring.

of the valley, in the vicinity of the present stream. It appears to be desirable that such a test should be made, and the circumstances seem to show that the most favourable place would be about two miles above the bridge over Guichon Creek, near the point of intersection of the creek with the south line of the present map-sheet.

Coldwater beds near Clapperton Creek.

The information gained respecting the second of these northerly projections of the Tertiary rocks, that to the west of Clapperton Creek, depends in large part on the examination of the Nicola Valley to the south of the area of the map. Its form, as shown upon the map, is probably nearly correct, but the depth of cover upon this part of the plateau renders it to some extent uncertain. It may extend somewhat further to the north, and its western edge may also lie somewhat further to the westward than represented. It is also quite probable that additional, but undiscovered, small outliers of these rocks occur on the plateau beyond its main area.

Sandstone outcrops.

Just beyond the border of the map, a mile and a half west of Mr. Clapperton's house, in the flat land of the valley, exposures of gray, siliceous sandstones like those associated with the coal at the mouth of the Coldwater are seen. These contain some pebbly bands, and dip westward at angles of about 20°, toward the base of the neighbouring hills. The thickness exposed is fully 100 feet. About 100 yards further west, on approaching the base of the steep hills, and on their slopes for some hundreds of feet up, Tertiary rocks are again seen, with prevalent easterly dips, at high angles, ranging apparently from about 40° to nearly vertical. The typical gray siliceous sandstones are not represented here, nor have they been recognized in any part of this area actually included in the map, which is occupied by rocks like those about to be noticed, which probably hold a lower position than the sandstones and represent the basal beds of the Tertiary at this place.

Conglomerates.

These rocks are in the main conglomerates, but are accompanied by finer grained materials, and from their somewhat peculiar character and their relations to the lowest members of the Tertiary elsewhere, require a few words of description. The upper beds are gray conglomerates, composed of well rounded pebbles thickly packed together. The pebbles are generally small, seldom more than a few inches in diameter. Compact cherty pebbles of pale tints predominate, but there is also a considerable proportion of hard black argillite. In the lower beds, the character of the conglomerates is considerably changed. The material is much less perfectly rounded, in many places resembling a breccia, and although it is somewhat varied in composition, much of

it is evidently of local origin and derived from the immediately underlying or adjacent beds of the Nicola formation, comprising gray, purplish, blackish and greenish porphyrite or diabase rocks. Fragments of granite rocks are also abundant and cherty material like that found in the overlying conglomerates is not entirely wanting.

Rough basal Conglomerates.

Fragments contained in these lower conglomerates were in some places observed to be as much as a foot or two feet in diameter. The fine-grained beds associated with them are essentially composed of similar material, which forms arkose or grauwacke sandstones. These are normally dark in colour and hard, but in many places they have been more or less decomposed and dolomitized, probably as a result of the action of heated waters from below, in a manner identical with that observed to have occurred in the case of the lowest Tertiary beds in some other parts of the region (see pp. 163 B, 125 B, 235 B).

Dolomitized sandstones.

As a result of the peculiar composition, excessive induration and local alteration of these basal beds, their relation to the Tertiary coal-bearing rocks of the vicinity is not at first apparent, and their line of contact with the unconformably underlying rocks can only be traced out in detail with difficulty. The rock immediately underlying these basal Tertiary beds, where seen near the wagon-road, about four miles south-west of Mr. Clapperton's house, is a dark purplish-black porphyrite, speckled with small light marks representing decomposed felspar. This forms an abundant constituent of the basal conglomerate of the vicinity. Further north, on the summit of the plateau, where crossed by our line of route as shown on the map, the basal conglomerates are underlain by a rather coarsely porphyritic purplish rock. This is an augite-porphyrite with an abundance of felspar crystals and holding a little quartz. It is easily recognized as forming a great part of the material of the conglomerates in its vicinity, and often occurs in large fragments in them. On the east side of the Tertiary area, where it runs up on the plateau, hard brecciated, greenish, felspathic rocks appear to bound it. It is probable that the junction is here a faulted one, the line of fault running nearly north-and-south. When last seen to the north-west, on the plateau, the basal beds, here comprising a good deal of rather soft brownish arkose sandstone, dip north-eastward at low angles. Elsewhere, the dips are almost invariably high, a circumstance apparently due to local folding nearly parallel to the supposed line of fault.

Area difficult to define.

Local constituent of conglomerates.

Probable fault.

Altogether, the stratigraphical relations of the beds in this vicinity is confused and somewhat perplexing, but it is sufficiently clear that we have here the overlap, upon the pre-existing surface, of a portion of the

Genera relations.

lowest beds of the Nicola-Coldwater coal-bearing rocks (Coldwater group), representing a part of the shore of the lake in which these beds were laid down. The thickness of the conglomerates and associated beds could not be precisely estimated, but must be at least several hundred feet.

Horizon.

All the beds here particularly described are undoubtedly below the known coal-bearing horizons of the vicinity, and there is very little prospect of the discovery of coal in connection with them. This does not apply, however, to the gray siliceous sandstones seen in the flat land a mile and a half west of Clapperton's, and it is possible that coal seams might be discovered by boring in this part of the valley.

Correspondence with other localities.

The notes above given, will show how closely analogous the basal beds of the Tertiary at this place are to those already described in the neighbourhood of Kamloops Lake (pp. 160 B, 163 B). The basal conglomerates are almost identical in character, with only such differences as result from the local nature of their material in each case. The overlying cherty conglomerates are even more nearly alike, and the problem presented by the occurrence of cherty material in so great quantity is the same in each case. Here, as elsewhere, volcanic materials referable to the Tertiary period are entirely wanting in the conglomerates, as they are also in the sandstones of the Nicola-Coldwater coal basin throughout its extent.

Places Suitable for Boring in Search of Coal.

Position of Coldwater beds.

From a practical point of view, the main result to be derived from the working out of the stratigraphical order and details of the flexures of the Tertiary beds of the Nicola Valley, is a knowledge of the localities in that valley in which coal-seams may reasonably be looked for. What has been said in previous pages, and more particularly in the account given of the composition of the Tertiary as a whole, will have rendered it evident that the Coldwater beds, with which the coal is associated in this district, represent portions of a sedimentary formation filling hollows, either those occurring in the preëxisting surface, or those produced by the folding or faulting down of the formation.

Possible existance of coal on Lower Nicola.

Some account of the Nicola-Coldwater coal basin and of its extension in the lower part of the Guichon Valley has already been given. Further to the north-westward, the coal-bearing beds are nowhere seen along the Nicola Valley. Where, in a couple of places, the underlying rocks come to the surface, the strata of the volcanic Tertiary, overlap them without the intervention of the Coldwater beds, and these, if

present, occupy the lower parts of hollows of the old surface which have not been exposed by the later folding and denudation.

Thus, to the westward of Guichon Creek (where the site for an experimental boring has already been indicated (p. 193 B), it is only possible to note a few places in which the lowest volcanic beds of the Tertiary come near to the surface, and where, by means of boring, it can be ascertained, at least cost, whether the coal-bearing Coldwater beds underlie them or not. Further, were the Coldwater beds actually found to occur in any of these places, it does not by any means necessarily follow that they would continue to be coal-bearing; for the coal-seams are the result of the accumulation of large quantities of vegetable material, and the swampy areas in which such accumulation took place must have been bordered on all sides by higher and drier lands of which the vegetation decayed as it was produced, and without leaving any trace.

The following places may, however, be mentioned as those in which it is desirable that experiments by boring should be made, and where, if coal should be found to exist, it may be more easily utilized, because nearer to the main line of railway communication through the country. Places suggested for experimental boring.

1. Nicola Valley from three-quarters of a mile to a mile east of the road-crossing of Skuh'-un Creek.

2. Nicola Valley, near the bridge at its mouth, or within half a mile above the bridge. At both these places it is believed that a boring would begin, at the surface, at a horizon low down in the volcanic accumulations of the Tertiary, and would within a few hundred feet reach the base of these rocks. Whenever the older underlying rocks may be reached, in either place, the boring should stop, but some care would require to be exercised in the recognition of these rocks, as they do not always differ very markedly from some of the Tertiary volcanic materials.

3. Mouth of the Nicoamen River, above the railway bridge and near the waterfall. It is not quite certain whether the beds containing some lignite or coal near Nicoamen are referable to the Tranquille horizon or to that of the Coldwater, but in either case the discovery of workable coal or lignite at this point would be of importance. The general section of the Tertiary rocks already given, will afford the means of deciding the horizon as any boring which may be made here progresses. It would be advisable to begin the boring as far up the stream as may be possible without materially increasing the elevation, in order to avoid the zone of crushing and disturbance which here characterizes the junction of the Tertiary rocks with the granitic

Possible auriferous gravels.

rocks. The possible occurrence of a buried pre-Miocene river-channel near this place, indicates the advisability of paying special attention to any beds of gravel or conglomerate which may be met with in boring, as these might be found to be auriferous.

Some other localities might be indicated as of subsidiary importance in connection with the search for coal, but those mentioned are, in so far as the structure of the region is understood, undoubtedly the first, (to the westward of Guichon Creek,) at which systematic boring operations might be made, and the results obtained should themselves go far to indicate both the advisability of further explorations and the places in which these should be conducted.

Tertiary Rocks of the Clear Mountains, Mount Murray, Arthur's Seat, Etc.

Tertiary volcanic range.

The mountains above designated, form a nearly continuous range, which may be regarded as running from the vicinity of Spence's Bridge on the Thompson for about twenty-six miles in a north-westward bearing. Chi-pooin Mountain and Mount Martley, the two most northern summits of the Clear Mountains, are not included here, as they are composed of granites and other rocks much older than those of the Tertiary.

Height of summits.

The range of Tertiary mountains thus defined, is a most important feature of the orography of the area included in the map-sheet. The Nicoamen Plateau may, in a general way, be said to form its further continuation to the south-eastward, but the heights at which the volcanic rocks occur in the range here particularly referred to, are greater even than those of the culminating parts of the Nicoamen Plateau—greater indeed than that of any other occurrence of similar rocks in the entire region. The elevations of the principal points in this range are as follow:—Arthur's Seat, 5500 feet; Mount Murray, 6880 feet; Blustry Mountain, 6740; Cairn Mountain, 7650 feet.

A line of volcanic eruption.

Although it has now been determined that the rocks composing these mountains are referable to the volcanic series of the Tertiary, and that they represent the basal portions of great accumulations of that kind formed along the main line of eruption, chiefly during its earlier stages, this result has not been arrived at without prolonged and careful investigation of all their relations in the field.

Earlier views respecting these rocks.

The area occupied by these rocks, being rugged and difficult of access, was necessarily left unexplored during the reconnaissance work of 1877, which was confined to a few months of a single summer. The

only place in which these rocks were then actually examined, was along the east side of the Fraser above Fountain Creek, and they were at that time, though with doubt, connected with the Cretaceous strata of the vicinity.* This was done because of their contiguity to the Cretaceous rocks and their lithological resemblance to certain "porphyrites" which had been found to contain Earlier Cretaceous fossils in the more northern parts of British Columbia in 1875 and 1876. At the other extremity of the area here under description, Arthur's Seat and adjacent mountains, seen only from a distance, were erroneously supposed to represent a continuation of the crystalline rocks of the southern portion of the Scarped Mountains. As the work upon which the present report is based progressed, it became gradually apparent that these rocks were not attached to the Cretaceous, and that although showing some points of resemblance to the volcanic materials of Triassic and Carboniferous age so extensively developed in the region, they were distinct also from these. Eventually, their intimate association with distinctly Tertiary volcanic products was established, and their connection with the older Tertiary volcanic rocks of the porphyrite class, as displayed along the Nicola River, became clear. Miocene age determined.

Without entering into details respecting the character and mode of occurrence of the rocks at each locality where they have been examined, it will now be attempted to give a short general sketch of them.

Arthur's Seat, so named by Mr. John Murray who has long resided near its base, at Spence's Bridge, is a remarkably picturesque mountain as viewed from the Thompson Valley, to which it presents a bold front crowned by lofty mural cliffs. The rocks of this mountain were to some extent taken as typical of those of the whole range which is continued north-westward by Mount Murray and the Clear Mountains. Its crest was not actually reached by us, though this might easily be accomplished from the westward if desired, but very large blocks which had fallen from all parts of its face were examined on the side of the Thompson, its southern flank was crossed at a high elevation, and the rocks of its northern side were examined and collected along the line of Murray Creek. Of the rocks obtained at these localities, a number have been subjected to microscopical examination by Mr. Ferrier, and the greater part of these have been found to be augite-porphyrites, with some diabase-porphyrites and gabbro.† In colour they range from grayish-green to bluish-gray, and Arthur's Seat. Characteristic rocks.

* Report of Progress, Geol. Surv. Can., 1877-78, p. 111 B.

† Appendix I., Nos. 47, 49, 51, 42.

in texture from fine-grained rocks of which the porphyritic structure is scarcely visible macroscopically, to others with a fine-grained base in which felspar crystals are clearly discernible, and again to crystalline rocks of a distinctly speckled or spotted appearance throughout. Some of these rocks are evidently fragmental in structure, but most of them appear to represent old flows of molten matter.

Murray Creek.

At the waterfall near the mouth of Murray Creek, the rocks are very much shattered and conspicuously reddened. They consist of porphyrites and of a trachyte-like material, one being in all probability intrusive in the other, but the broken character of the exposures renders it difficult to determine which of them is the older at this place.

Skoon-ko' Valley.

On the upper part of Skoon-ko' Creek, to the west of Arthur's Seat, the rocks displayed are somewhat more varied in character and are distinctly arranged in somewhat massive beds, which dip at rather low angles, but of which the direction and amount of dip is irregular and difficult to follow. The order is in general, however, an ascending one, from lower to higher levels on the hills. The hill side to the north of the valley was ascended by Mr. McEvoy at two places indicated on the map. At the first of these, the general dip appeared to be southerly at angles of 10° to 30°. The lowest rock seen is a bluish-gray, much decomposed, amygdaloidal augite-porphyrite.* This is overlain by a fine-grained, greenish-gray agglomerate, followed by a distinctly bedded pale, tuffaceous rock. At the second locality, some ordinary sedimentary sandstones occupy the bottom of the valley. These underlie the volcanic rocks and will be referred to again in the sequel. Above them is a fine-grained, yellow amygdaloid, then a pale gray trachyte-like material, then some brown and greenish rocks which were classed in the field as "basalts," but of which no specimens were brought back. Overlying these are beds of rather fine-grained agglomerate, composed chiefly of porphyritic fragments of gray, brown and purplish colours. Some of these fragments are evidently derived from massive rocks in the lower part of the series, seen along the valley of the stream between the two localities above specially noticed.

Scarped Mountains.

The northern part of the Scarped Mountains, to the south of Arthur's Seat, appears to consist of rocks very similar in character to those of that mountain, in so far as they have been examined. Along the west side of the Thompson south of Skoon-ko' Creek, bluish and greenish-gray porphyrites of varied texture, generally massive, but sometimes agglomeritic, are characteristic. On the west side of these

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* Appendix I., No. 50.

mountains, the general dip of the volcanic rocks in the mass, was very clearly seen from Botanie Mountain, whence their outcrops can be traced along the hill-side to the east of Botanie Creek. The dip is about east-north-east at angles of from 15° to 30°. The rocks themselves were not here closely examined, but specimens representing the lower members, near to the bottom of the valley, were obtained in three places, as follows:—Half a mile below Botanie Lake, a fine-grained, purple-gray felspathic rock with flow-structure. Two miles below Botanie Lake, a fine-grained, dark augite-porphyrite (?) with green-faced divisional planes. Four miles and a half below Botanie Lake, a gray porphyrite.

Botanie Valley.

The southern line of the volcanic rocks, crossing the Scarped Mountains, as shown on the map, depends chiefly upon distant views of these mountains from Botanie and Lytton mountains. It was not actually traced across this rugged range, and may therefore be held subject to modification in detail. The summit, marked "5860 feet," in particular, was referred with doubt, from its appearance, to the granitic series.

State of underlying granites.

The Tertiary volcanic rocks appear to have been stripped from the southern part of the Scarped Mountains by denudation, but the underlying granitic and gneissic materials bear evidence of the proximity of the great line of volcanic eruption in their extremely shattered and disturbed character. They are traversed by numerous dykes of trappean material, fractured throughout in every direction and much altered by heat or solfataric action.

Mount Murray.

Mount Murray, at the head of Murray Creek, was occupied as a point of observation and a triangulation station. It is composed of rocks evidently the same as those seen along the valley of the creek and in Arthur's Seat. They are generally gray or greenish-gray porphyrites, usually massive, but often distinctly fragmental, and constituting agglomerates. Along the crest of the mountain, near the summit, some red fine-grained beds with small porphyritic crystals occur, which are nearly horizontal; but generally it is not possible to determine the lie of the beds. The actual summit is composed of a gray augite-porphyrite.*

From Mount Murray, an execellent view of the whole surrounding region and particularly of the southern parts of the Clear Mountains proper, was gained.

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* Appendix I., No. 52.

Botanie Valley. Sandstones.

The western edge of the volcanic rocks, approximately follows the line of the valley in which Botanie and Pasulko lakes are situated, and between these lakes are some interesting outcrops of ordinary sedimentary materials which underlie the great volcanic mass. These appear to consist of sandstones and argillites not distinctly containing volcanic materials, but holding occasional carbonaceous fragments and obscure plant impressions. Conglomerates also occur, and these were particularly observed on the north branch of La-loo-wissin Creek, where they pass into ordinary sandstones of pale yellowish colours. The approximate outcrop of these sedimentary beds is indicated on the map, and though their precise age remains uncertain, it is probable that they may be regarded as forming an extension of the sedimentary beds met with in Hat Creek and described on another page (p. 207 B).

Plateau near Lookout Point.

To the north-eastward of Murray Creek and Mount Murray, the Tertiary volcanic rocks continue over a tract of country about five miles in breadth, extending from the Thompson River to the headwaters of Hat Creek, with a length of some fifteen miles. This tract is high and rough, but with some tendency to a plateau-like character as seen from Mount Murray. Lookout Point, rising from it, reaches an elevation of 6600 feet.

Character of line between basalts and porphyrites.

The greater part of this area is believed to be characterized by rocks referable to the earlier stages of the volcanic eruptions, and like those described in the foregoing pages of this section of the report. Its north-western part is, however, evidently covered by basaltic rocks in nearly horizontal flows. The attempt made on the map to outline these two classes of rocks in this region and in that of the Clear Mountains, must be accepted rather as an indication of their existence than as an actual definition of their areas, for no sufficiently detailed examination of their boundary has been made. The exploration of the tract of high country here particularly referred to, was in fact confined to the vicinity of Murray Creek, the Thompson River, Twaal Creek and Blue-earth Creek. The rocks met with on the line of Murray Creek have already been noticed, but a few words may be added respecting those seen on the other routes mentioned.

West side Thompson Valley.

On the west side of the Thompson, the north-eastern edge of the Tertiary is nearly opposite In-kai-kuh' Creek, where its beds are found in contact with black slaty argillites and quartzites of the Câche Creek formation. Porphyritic dykes, evidently due to the period of Tertiary eruption, traverse the older rocks near the line of junction, and the Tertiary volcanic rocks near their margin are found to be much disturbed. The junction is probably here a faulted one, the fault being

the same with that which runs so persistently to the north-east of the Nicola Valley,

Near the edge of the Tertiary, a well bedded intercalation of green-gray tuffaceous sandstone appears, dipping S. 35° W. < 60°. The exceptionally high dip is explained by the proximity of the fault. This stratified intercalation was not recognized on the opposite or east side of the Thompson, but about a mile further south (half a mile above Twaal Creek), another outcrop of similar tuffaceous sandstone occurs on the west side of the river. This dips S. 65° W. < 30°. It was estimated to be about one hundred feet in thickness, and is evidently the same with that noted on the east side of the river, opposite (p. 188 B). Tuffaceous sandstones.

Below the mouth of Twaal Creek, considerable exposures are found of a peculiar gray concretionary rock not elsewhere seen in the Tertiary. This is described by Mr. Ferrier as a quartzless porphyry (orthophyre) with well marked spherulitic structure.* The other rocks seen along this part of the Thompson are greenish and gray porphyrites of the usual character, occasionally fragmental. Orthophyre.

Similar rocks occur along the Twaal Valley, with the addition of some reddish-gray porphyrite, and in one place of a gray dacite which contains numerous large grains of quartz with rounded outlines.† Twaal Valley.

The bedded tuffaceous layers seen on the Thompson were not found in this valley, but the hillsides along it are rather heavily drift-covered, and the exposures in consequence imperfect. At the head of the valley the volcanic rocks are in contact with the limestones of the Câche Creek formation, but it was not ascertained whether the line of junction continues to be a faulted one here.

Blue-earth Creek heads in the same valley as that in which Twaal Creek rises, but flows in the opposite direction, to Hat Creek. This part of the valley nearly coincides with the edge of the Tertiary volcanic rocks, which occupy the country to the south, while the north side of the valley is characterized by limestone, often in the form of bold cliffs. The step-like outlines of the high plateau rising toward Lookout Point, to the southward, indicate that it is chiefly composed of basalts or similar rocks in nearly horizontal flows, and different varieties of such rocks are found on the slopes toward Blue-earth Creek. At one place, just below the little lake in which the creek rises, the Tertiary rocks seen actually resting on the limestones, consist of yellowish and greenish-blue soft tuffaceous deposits, contain- Blue-earth Creek. Local base of volcanic rocks.

* Appendix I., No. 43. † Appendix I., No. 49.

ing fragments of basalts and hard concretionary masses of the same blue colour. This material appears to have been deposited against an originally steeply sloping surface of the limestone; but there is nothing to show that it is at all near the true base of the Tertiary formation.

Southern part of Clear Mountains.

The valley which runs from the head of the north branch of La-loo-wissin Creek to the head of Hat Creek, may be regarded as separating the Clear Mountains proper from Mount Murray and others previously described. As seen from the summit of Mount Murray, the high broken region forming the southern part of the Clear Mountains shows the well marked outcrops of massive volcanic beds dipping at low angles to the northward. The same observation was repeated in views had of the western side of this part of the range from As-kom Mountain, on the opposite side of the Fraser, and from a ridge on the east side of the Fraser, in its valley and near the mouth of Cinquefoil Creek. From the two last mentioned places, however, the relation of these rocks to those of the granite series was also very clearly made out, the scarped hill sides sloping toward the Fraser Valley being composed in their lower parts of granite and diorites, upon which, further back and at a greater height above the river, the volcanic materials rest often nearly horizontally. As seen from the Fraser Valley, the overlying volcanic rocks often appear to form rugged and bold hills, but when viewed from a greater elevation, these are found to be merely the scarped ends of ridges and spurs fringing the broken edges of the central part of the range.

FIG. 5.—DIAGRAMMATIC SECTION NEAR THE MOUTH OF CINQUEFOIL CREEK.

a. Granitic and dioritic rocks. *b.* Cretaceous. *c.* Volcanic rocks of the Tertiary.

Shattered underlying granites.

Along the Fraser Valley, from the vicinity of La-loo-wissin Creek to that of Cinquefoil Creek, the underlying diorites and granites are extremely shattered, and weather down easily into rubbly slopes of angular débris. These rocks are in fact affected in a manner precisely similar to those of the southern part of the Scarped Mountains (p. 201B), and like them represent a portion of the old floor upon which the volcanic accumulations occurred, near to the central line of eruption.

Summits of the Clear Mountains.

The summit of the Clear Mountains was reached, by following up the valley of a small stream which empties into Hat Creek opposite Blue-earth Creek. So far as examined, the eastern flanks of the range, all

along the upper part of Hat Creek, are largely composed of basaltic rocks, while similar rocks occur high up on the north-eastern flanks of Cairn Mountain, and also in several (or many) other places along the range. On the map, it has been possible to indicate these occurrences only in a general way, or in certain special localities in which they have been observed. Here, as elsewhere, the distinction made between the older and newer volcanic rocks must be considered as approximate merely, and as being much inferior in accuracy to the outlines of the Tertiary rocks as a whole. The rocks observed on the higher parts of the Clear Mountain range, may be described as consisting in the main of gray, blackish, purplish and greenish-gray porphyrites, probably for the most part augite-porphyrites. They are often massive, and represent eruptive materials, but agglomerates of similar composition are also common. The occurrence of basaltic rocks on the eastern flanks of the range has just been alluded to. On the western slopes of Cairn Mountain, two or three distinct outliers of similar rocks were observed, which still preserve their slope, away from the axis of the range and toward the Three-lake Valley. Certain purplish porphyrites which are somewhat less compact in texture than usual, appear to immediately underlie the basalts, while the dense and hard, gray and greenish porphyrites, occupy lower positions in the series and are prominent about the crests of the range.

Basaltic outliers.

A notable feature in the higher parts of these mountains and toward their axis, is the abundance of yellowish and whitish crumbling rocks, which give rise to slides of broken material of the same colours, very conspicuous from a distance. These, on investigation, proved to be merely portions of the ordinary porphyrites which had become highly charged with iron pyrites, and which, in part from the decomposition of the pyrites and the action of the liberated acids on the containing rocks, in part apparently from solfataric action which may have occurred during the deposition of the pyrites, have become decomposed and bleached. Decomposed rocks of this character were found to be particularly abundant in the vicinity of Cairn and Blustry mountains. Specimens of them were collected and subjected to analysis, in order to ascertain whether they might contain any gold, but they proved to be barren. The pyritization and decomposition of the rocks here referred to, may be supposed to have occurred during the period of decadence of the volcanic forces to which the formation of the Clear Mountains as a whole is due.

Masses of decomposed rocks.

Rocks tested for gold.

Some miles to the north of Cairn Mountain, the Clear Mountains were crossed by ascending the valley of Limestone Creek and descending from its sources to the Three-lake Valley. Limestone Creek and the

Limestone Creek.

gap through which the summit is crossed, coincide as nearly as possible with the northern edge of the Tertiary volcanic rocks of this place, the mountains to the north being composed of limestones and associated Palæozoic rocks, with granite. Beyond the summit, on the west side, the route followed leaves the valley of Eleven-mile Creek at its head and descends along spurs composed of the volcanic rocks toward the Three-lake Valley. On this route, the volcanic rocks met with are chiefly grayish and purplish porphyrites of the usual kind, but near the summit, a small area of basalt was observed.

Three-lake Valley.

To the west of the Clear Mountain range, the Three-lake Valley has been excavated along the line of junction of the Tertiary volcanic rocks, with those of the Cretaceous series which constitute Fountain Ridge. Some difficulty is occasionally found, in small exposures, in separating the porphyrites of Tertiary age from the largely felspathic sandstones and grauwackes of the Cretaceous, but the valley as a whole appears to follow the line of contact very closely.

Decomposed and shattered rocks near Fountain.

On the Fraser River, to the north of Three-lake Valley and east of the mouth of Fountain Creek, the junction of the Cretaceous rocks with the volcanic Tertiary rocks of the Clear Mountain mass, is obscured by considerable disturbance and alteration. Both the Cretaceous sandstones and the volcanic rocks have been discoloured and silicified by heated water or vapours, subsequent to the date of their deposition, but as a result of a careful examination on the ground, the boundary has been laid down as it appears on the map. Where unaltered, the volcanic materials are found to be gray and purplish porphyrites of the usual character. These are seen on Eleven-mile Creek, near the wagon-road and elsewhere in the vicinity. The boundary of the Tertiary volcanic rocks on the upper part of Eleven-mile Creek and to the east of the Fraser, for a couple of miles north of that stream, is not so definite, as it was not actually traced out in detail on the ground.

Fountain to Pavilion Creek.

The volcanic rocks here, however, form a narrow band along the Fraser Valley, while the northern part of the Clear Mountains consists of Palæozoic and granitoid rocks, and the Camelsfoot Range, to the west of the Fraser, is Cretaceous. About a mile south of Eighteen-mile Creek, some decomposed volcanic rocks remarkable for their brilliant and varied colouring, appear on the east of the road and between it and the Fraser River. At the mouth of Pavilion Creek, the Tertiary volcanic rocks have a width, to the east of the Fraser, of about a quarter of a mile only.

Less than a mile north of Fourteen-mile Creek and just east of the wagon-road, a small patch of rather soft, coarse conglomerate occurs. Most of the boulders and pebbles consist of porphyrite rocks like those of the Clear Mountains, while some are granites. The height of this little outlier above the Fraser is about 1000 feet, and it appears to represent a remnant of an old bed of the Fraser, which, perhaps owing to some local induration, has escaped denudation. The height above the present river seems to indicate that it may be assigned to one of the early stages of the period of Pliocene erosion. This, with any other similar deposits which may be found, appear to be worth examining as possibly containing gold brought down during the period of ancient river erosion.

Pliocene conglomerate.

Possibly auriferous.

Tertiary Rocks of Hat Creek, Pavilion Mountain and Vicinity.

The upper valley of Hat Creek, which runs from south to north along the east base of the Clear Mountains, is largely floored by sedimentary Tertiary beds—generally soft shales and sandstones. The whole surface of this wide valley is, however, so thickly covered with drift deposits, that it is impossible to define the area of these Tertiary beds with any precision. The outline given upon the map is probably as nearly exact as is possible from observation of the natural exposures, but it is really only in that part of the valley near Limestone and Medicine Creeks, and thence northward, that the Tertiary sedimentary deposits are actually exposed. Thus, the southern extent of these beds, and their width in the southern part of the valley is particularly open to doubt.

Hat Creek.

The occurrence of an important deposit of lignite-coal on Hat Creek, near the east entrance of Marble Cañon, has long been known. This locality was visited by me in 1877, and some description of it is given in the report for that year, from which the following is quoted :—

Great bed of lignite.

" A locality of some interest in connection with the Tertiary is found on Hat Creek, about a mile above its abrupt bend at the eastern entrance to Marble Cañon. The exposures here extend for about 500 yards along the stream, but are not continuous, and the arrangement of the beds is somewhat complicated by the fact that considerable landslips have occurred in some parts of the banks. These have formed hollows beyond the margin of the bank, in two of which pools now lie. A great thickness of lignite coal, however, occurs here, associated with sandy or clayey, yellowish, grayish or purplish beds, which are generally rather incoherent. The stream nearly follows the strike of the beds, so that the same deposit of lignite is seen in a number of

Description from Report of 1877-78.

places. The lowest good exposures shows over thirteen feet of lignite, neither the top nor the base of the bed being seen. The lignite is pure throughout, with the exception of a few lenticular or more or less irregular masses formed by silicified or calcified stumps. In following up the stream, lignite of the same kind is frequently seen, and continues to show occasional masses of fossil wood of the kinds above described, but is without shale. Some portions of the wood have been changed to ironstone of good quality, which might be of value if the lignite bed were being worked. At the highest good exposure the beds are dipping into the western bank of the brook at an angle of 30°, and are probably undisturbed. The bank was here scarped down, and the section carefully examined. The result may be stated as follows, in descending order :—

Natural section observed.

	Feet.	In.
(1.) Grayish and brownish shales and sandy clays, with lignite in seams a few inches thick, about.	20	0
(2.) *Lignite*, with shaly and lenticular layers of siliceous matter, ironstone and shale. Lignite of fair quality forms about two-thirds of the whole, and contains much crumbling amber..........	26	0
(3.) *Lignite*, with little or no shale or other impurity. Below very compact, rather softer in the upper layers.....................................	42	0
	88	0

"The bottom of this enormous lignite bed was not seen, the measurement going only to the water of the brook, beneath which it is concealed."

Work done in 1889.

In 1889 some attempt was made, by drifting and uncovering the outcrops, to determine the extent and value of this lignite deposit, but the amount of work done was inconsiderable and the additional information gained by it not great. The openings were visited by me in the same year, when attention was also directed to ascertaining the limits and character of the field as a whole. The paucity of information to be derived from the exploratory work, results chiefly from the fact that the beds are much disturbed where they outcrop along the banks of this part of the stream, and that an even greater amount of disturbance and irregularity has been brought to light by the work done, than could have been previously anticipated. This disturbance may possibly be entirely due to the effect of old (perhaps pre-glacial) slides, affecting a former escarpment of the soft rocks, along the base of which the stream was working. Part of the irregularity is certainly attributable to this cause, but I am inclined to believe that there is as

Disturbed strata.

well some faulting parallel to the line of the stream, or that the softer beds have here been crushed by pressure, at their line of contact with the more resistant old rocks, as so often occurs.

At the point where the principal openings were made, the lignite and associated shales were found to dip S. 55° W. < 60° or even higher. A drift run in here for eighteen feet, passed through practically solid lignite for nearly that distance, when shales and sandstones dipping in an opposite direction, at an angle of about 45°, were encountered. As it is scarcely probable that the lignite here occupies so narrow a synclinal fold, it is likely that it is either slipped or faulted down to the eastward on the shales and sandstones found at the end of the drift.

Measures probably regular west of Hat Creek.

The stream and the exposures along it, are here close to the east side of the wide valley, the floor of which slopes gradually up westward to the base of the Clear Mountains. The slope thus formed is lumpy and irregular in detail. This is probably due in part to old landslides, in part to morainic accumulations and irregularly disposed drift materials, with which the surface is in general covered. The stratified Tertiary rocks are scarcely seen in place, but they are frequently represented, for nearly two miles, by yellowish soft shales, poached up and disturbed, but evidently not far moved. The highest appearance of such materials noted, was at about 650 feet above the level of Hat Creek, and on the assumption that the beds are in the main horizontal, the thickness of the sedimentary beds must be at least thus great. A little higher up, thick beds of vesicular basalt are found capping the softer materials and running back to the steep base of the Clear Mountain range. The rocks composing this part of the range are granites, and to the north of Limestone Creek the volcanic materials were observed to rest directly on these by overlap. The surface of the granite is here somewhat decomposed and soft, and slopes toward the valley at an angle of nearly 20°. The rock actually in contact with the granite, at one place, was found to be a melaphyre, with well marked flow-structure and including in its mass numerous small fragments picked up from the granite.

Basalt capping.

Other basalt remnants.

The basaltic flows have probably at one time entirely covered the sedimentary Tertiary rocks of this part of Hat Creek valley, for extensive remnants of them occur at nearly corresponding elevations on the opposite or east side, where they form a step-like border to the Palæozoic rocks of the higher hills.

Age of sedimentary beds.

The sedimentary rocks here observed, in their general appearance and in the conditions of their occurrence, closely resemble those already

described on Guichon Creek (p. 192 B). They were not observed to contain any contemporaneous volcanic materials, and it is highly probable that they are referable to the Coldwater series of the classification adopted in this report. No determinable organic remains have been found in them.

Relation to beds of lower valley.

The natural exposures do not serve to satisfactorily connect the sedimentary beds of this part of Hat Creek valley, with the conglomerates and sandstones of the lower part of the valley, which undoubtedly represent the Coldwater beds; a gap of more than a mile occurring between them, for which there is no information. While it is possible that the two areas are continuous along the bottom of the valley, it has been thought better to represent them on the map as being disconnected. It is believed, however, that the beds seen on the upper part of Hat Creek represent the higher parts, while those on the lower part of the creek represent the lower parts, of a single series of Tertiary deposits. The conglomerates were nowhere seen in place in the upper part of the valley, but large, loose pieces of conglomerate, identical with that of the lower valley, were found some miles above the lignite outcrops on the creek.

The Tertiary volcanic rocks, last seen at about a mile and a half below the bend made by Hat Creek at the entrance to Marble Cañon, are basalts, apparently brecciated, underlain by purplish melaphyre identical with that described as overlying the granites near the mouth of Limestone Creek, and probably an extension of the same flow.

Character of lignite.

In regard to the composition of the lignite here met with, the following assay by Dr. Harrington may be quoted from the report of 1877-78 (p. 121B):—

Water	8·60
Volatile combustible matter	35·51
Fixed carbon	46·84
Ash	9·05

For a lignite, the fuel is therefore of good quality, and the great thickness of the bed should render it of some importance, at least locally.

Site recommended for boring.

As a result of the observations made on the mode of occurrence of the lignite and its associated rocks, it would appear to be desirable to abandon further exploratory work in the disturbed measures near the eastern edge of the valley, and to make a test by means of a boring, put down at a distance of a quarter or a third of a mile to the westward of the locality on the stream at which work has already been

done. From analogy with the Nicola Valley occurrences, it is quite possible that in beds beneath the lignite already known, fuels of the character of true coals may yet be found. Whether this is or is not the case in this locality, can be determined by boring only. It is further to be remembered, that the lignite-bearing rocks, if correctly referred to the Coldwater series, should here extend beneath the great volcanic accumulations of the Clear Mountains. This implies, that anywhere to the south of Limestone Creek, the mountains bordering the valley do not necessarily mark the limit of the lignite-bearing series in a westerly or southerly direction.

Possible occurrence of coals.

Before leaving this part of the Hat Creek valley, a word may be said respecting some possibly Pliocene materials met with in one place. These occur on the small stream which flows into Hat Creek opposite Blue-earth Creek, about a mile above its mouth. They consist of conglomerates, composed chiefly of well rounded basaltic pebbles, many of which are vesicular basalt. There are also some thin layers of dark gray sandstone made up of comminuted basalt. These materials are evidently water-bedded, and from the large proportion of basalt they contain, are probably later in date than the main period of volcanic activity. The thickness of these beds actually seen is about fifteen feet only, and their extent was not ascertained. They occur at an approximate elevation of 4500 feet, and dip, or slope, eastward, at a very low angle, toward the axis of the valley.

Beds regarded as Pliocene.

To the south of Pavilion Creek, and high up on the shoulder of the mountain between that creek and the valley of the Fraser, a small patch of Tertiary sandstones was found. This has a greatest length of about three miles, and occupies a nearly level area of not more than a mile in width. Its general elevation is from 3000 to 3500 feet above the sea-level. The sandstones are gray on fresh fracture, weathering to yellow tints, slightly calcareous, and apparently composed of arkose material derived from the weathering of granitic rocks. They hold some thin conglomeritic layers, are nearly horizontal, and have probably a thickness of several hundred feet, though the greatest actually observed thickness was about 50 feet. Some shaly fragments, apparently referable to Tertiary rocks, are contained in them, and shaly or clayey beds probably occur in association with them; for where they come to the high edge of the Pavilion Creek valley, they have supplied the materials for a great, old landslide, which in a succession of wave-like ridges and mounds has covered the whole slope down to the level of the creek itself, near the Indian village. No volcanic rocks are associated with this outlier and we have no means at this place of deter-

Sandstone area south of Pavilion Creek.

Old landslide.

mining its position in the Tertiary series; but in all probability, it may be considered as representing a part of the extent of the sandstone which is found underlying the basaltic plateau at a similar level, on the opposite side of the Fraser near Leon Creek (p. 216 B).

Tertiary outlier of Pavilion Mountain.

Another Tertiary outlier, of larger dimensions, occurs on the opposite or north side of Pavilion Creek, covering a wide sloping area on the south-west flank of the Pavilion Mountains at 3500 to 4500 feet. Its area is characterized by flat land or by light undulating slopes, and is occupied by several good farms. It is thickly drift-covered, and in consequence its actual outlines are fixed only approximately and with difficulty. Loose blocks of yellowish sandstone, like that last described, were observed, while basaltic rocks were seen to form a scarped outcrop overlooking the valley of Pavilion Creek to the west of Capt. Martley's house. The Tertiary area is here characterized by a notably red soil, and it would appear that the immediately underlying beds consist of volcanic, and chiefly of basaltic, materials, derived from the crumbling surfaces of recently erupted rocks of that class, arranged in beds in some body of water which at the time covered the region. The relations of the yellowish sandstones, the basalts and the reddish superficial beds, were not definitely ascertained, but it is believed that the last-mentioned beds may be of Pliocene age, and possibly synchronous with the basaltic conglomerates already mentioned as occurring in the upper valley of Hat Creek. The actual elevations of the two places nearly correspond.

Section on Lower Hat Creek.

The lower part of Hat Creek, cuts obliquely across an area of Tertiary conglomerates and sandstones, which on the line of section has a width of about five miles (See section No. 6). The underlying rocks, on the side toward Marble Cañon, are chiefly limestones, those on the opposite or east side, chiefly cherty quartzites and dark argillite-schists. The Tertiary rocks form two main synclines, separated by a narrow projection of limestone and greenish felspathic rocks, which appears to be covered by the Tertiary rocks not far to the south of the valley, as represented on the map. The west edge of the Tertiary area, is found about three miles and a half below the bend made by Hat Creek at the east end of Marble Cañon, where the rocks overlapping the limestone consist of a conglomerate, chiefly composed of limestone fragments but also containing pebbles of chert and other rocks. The beds are firmly coherent, and weather reddish. To these succeed, in ascending order, a great series of sandstones and conglomerates, the materials of which have been for the most part derived from the cherty quartzites of the Câche Creek formation. The cement is calcareous, and the usual colours of

the rocks greenish-gray, gray or brown. The conglomerates are sometimes lenticular, but on the whole the beds are extremely regular. They are nowhere very coarse. Shales seldom occur, nor were any tuffaceous or other beds of volcanic origin observed. The beds dip in most places at angles of 30° to 50°. The thickness of the entire series as here found is about 5000 feet.* Thickness represented.

To the south of the line of section above described, the conglomerates and sandstones run for some eight miles, to the trail which crosses from McLean Lake to Medicine Creek. They form a high, broken, hilly country, of which the Trachyte Hills are the culminating point. The exposures are nowhere so good as those in the valley, but the lithological character of the beds continues the same, though the angles of dip are generally lower. The highest part of the Trachyte Hills, with an elevation of 5200 feet, is composed of a fine-grained homogeneous, white mica-andesite, showing foliation or flow-structure running in various directions through it.† It is not certain whether this forms an outlier of an old flow, capping the conglomerates, or whether it marks the site of a local eruption cutting through these beds. Continuation southward. Trachyte Hills.

South of McLean Lake, a small outlier of the conglomerates was found, in a rough, broken country heaped with morainic matter. Its precise extent remains indeterminate. McLean Lake.

The small detached Tertiary outlier shown as capping Campbell's Hill, consists of brownish vesicular basalt. Campbell's Hill.

A very small patch of Tertiary rocks, not more than a few acres in extent, occurs on the east side of the Bonaparte River about three miles and a half from its mouth, or two miles and a half from Câche Creek. This lies on the sloping side of the valley and its bedding conforms to the slope. The lower beds are argillaceous and carbonaceous shales with whitish sandstones, and these contain one or two seams of lignite, never more than a few inches thick. The whole thickness of the stratified materials can not be much more than fifty feet. They are capped by basalt, somewhat irregularly columnar and about a hundred feet in thickness. The regular bedding of the stratified materials, shows that they must originally have been horizontal or nearly so. Their present inclination, at an angle of about 25°, must therefore be a true superinduced dip, if the whole mass is not the result of an old slide from the edge of a formerly wide-spread deposit, the rest of which has been removed. Some well preserved specimens of silicified wood occur in this outlier. Small Tertiary outlier on Bonaparte.

* In part quoted from Report of 1877-78, p. 121 B. † Appendix I., No. 71.

Rocks to north of Lower Hat Creek.

To the north of the lower part of Hat Creek, the outlines of the western limb of the Tertiary rocks have been laid down almost entirely by means of distant bearings and sketches, obtained from the Trachyte Hills and from different parts of the Pavilion Mountains. The Tertiary rocks in this region, are sufficiently distinct in appearance from those of the Palæozoic, even at a distance. It is assumed that this area is characterized by conglomerates and sandstones, but it is at the same time possible that some part of it is occupied by volcanic rocks. What may be called the eastern limb, is somewhat better known. Where seen on the plateau between Hat Creek and Maiden Creek, it consists of sandstones and conglomerates. Where crossed on the line of Maiden Creek, the rocks are gray or greenish-gray sandstones and conglomerates, often in very massive beds and containing no shaly intercalations. Their thickness here is at least 500 feet. Further north, the same rocks are found to the west of Glen Hart, along which valley they appear in low mural cliffs. The last exposures of this kind were observed nearly abreast of the southernmost small lake in the valley. To the north of this point, the plateau-like area which has heretofore been occupied by the conglomerates and sandstones, is found to be covered by basaltic rocks, and it is not known whether the sedimentary rocks continue to underlie these. The level of this outlying basaltic plateau is from 1000 to 1500 feet above the Glen Hart valley.

Glen Hart.

Tsil-tsalt′ Ridge.

The southern part of Tsil-tsalt′ Ridge, between Glen Hart and the Pavilion Mountains, is capped by red-weathering volcanic rocks which are apparently chiefly basaltic. These rocks seem to slope down along the ridge to the southward, and on Maiden Creek, a small area of volcanic rocks was found to overlap the conglomerate and sandstone beds in horizontal layers. This is composed of hornblende-andesite.*

East side Pavilion Mountains.

To the north of the source of Pavilion Creek, a very small outlier of a whitish trachyte-like rock was found, patched upon the eastern slope of the Pavilion Mountains at a height of about 6500 feet above the sea. This may possibly be the same in composition as the andesite of the Trachyte Hills, which it resembles in appearance. It is foliated and dips eastward at low angles.

Hart Ridge.

The small Tertiary outlier which is shown on the map to occupy the northern part of Hart Ridge, must be regarded as very indeterminate in outline. Basaltic breccias were found at this place to cap the ridge, but the covering of drift materials is so thick, that it was impossible to ascertain how far southward such rocks may extend along

*Appendix I., No. 72.

the crest of the ridge, of which all the lower parts, on both sides, undoubtedly consist of much older rocks. Outcrops of schists found on the northern slopes of the ridge, show that these old rocks here occur to an elevation considerably greater than that of the base of the basalts on the neighbouring edge of the Green Timber plateau to the northward.

Round Lake near Clinton.

Small exposures of Tertiary sandstones, were seen in this vicinity at a much lower level, on the west side of Round Lake, in the northern entrance of the Glen Hart valley. It is possible that beds of this character may occupy a considerable area of adjacent parts of the wide Junction Valley, near Clinton, but this is entirely buried beneath drift deposits and later alluvium. The base of a sandstone deposit of this kind, occupying as it does the bottom of a great depression in the old schistose rocks, would appear to be a likely place in which to search for old Tertiary gold placers; but it might prove to be very difficult and expensive to reach and properly test it.

Deposits possibly auriferous.

Tertiary Rocks to the West of Fraser River.

Fountain to Red Creek.

From the vicinity of Fountain Creek, nearly to Red Creek, the Fraser approximately follows the line of junction of the Tertiary volcanic rocks with those of the Cretaceous series, the line being in fact the northward continuation of that along which the Three-lake Valley is eroded. North of Red Creek, the Tertiary rocks begin to occupy a considerable area to the west of the river, and to the north and west of the present map-sheet, this area appears to become even more important.

Red Creek to Leon Creek.

At the trail-crossing of Red Creek, purplish, gray, and greenish augite-porphyrites are found, and some of these rocks weather readily into crumbling slopes of bright red colour. From the crossing of Red Creek, as far as Leon Creek, the Tertiary volcanic rocks consist chiefly of gray, greenish, and purplish porphyrites, sometimes breccias. At the spring marked on the map, the rock is a hard fine-grained eruptive, probably a diabase-porphyrite, but not microscopically examined. Before reaching Leon Creek, basaltic rocks, rather sparingly seen further south, are found in nearly horizontal flows broken off at a considerable height above the river. The boundary between the Cretaceous rocks on the west, and the volcanic Tertiary rocks, is here remarkably distinct and straight, and follows a well-marked valley which is nearly parallel to that of the Fraser. There is some reason to suppose that this boundary may be a faulted one, but this s not certain.

Leon Creek.

On Leon Creek, two miles and a half west of the Fraser, Tertiary porphyrites are again found to replace the Palæozoic rocks, which here border the river. They are generally agglomerates, containing many amygdaloidal fragments and showing evidence of considerable disturbance. These volcanic rocks here appear to occupy the eastern edge of a basin, and, further to the west, beyond the limit of the map, similar rocks seem to form hills of some height.

Continuation of Clear Mountain axis.

Taken as a whole, the porphyritic rocks between Red and Leon creeks, appear to represent a continuation of those found in the Clear Mountain axis of eruption. On both sides of Leon Creek, they are capped by nearly flat flows of more or less distinctly columnar basalt, which when freshly broken has a purplish colour. These occupy a proximately level area of considerable extent, which breaks off at the edge of the great valley of the Fraser at an elevation of about 3000 feet, but which rises gradually to the westward, conveying the impression that the basaltic material flowed from that direction. About two miles and a half south of Leon Creek, where the basalts cap granitic rocks, a bed of sandstone was found to lie beneath the basalts in some places. The whole extent of this intercalation was not determined, but it is probably local. The sandstone is yellowish and rather soft, often coarse and sometimes pebbly. It is composed chiefly of angular granitic débris. (See p. 211 B.)

Basalts over lying sandstone.

North of Leon Creek.

North of Leon Creek, basalts similar to those just described and forming an extension of the same flow or series of flows, continue to cap the high hills on the west side of the Fraser as far as the edge of the map-sheet. The last isolated patch of basalt shown, in this direction, is part of a very small outlier. Further to the west and north, the hills fall back from the Fraser in the vicinity of Watson Creek, porphyrites like those of Leon Creek are again seen in them, though the rocks immediately bordering the river are continuously Palæozoic, nearly or quite to the mouth of Big Bar Creek.

Sources of basalt flows.

The remnants of old basalt sheets found high above the Fraser along this part of its valley, together with those of the head-waters of Big Bar Creek, probably represent flows of proximately local origin, and have proceeded from sources different from those which flooded the Green Timber plateau. In any case, their present appearance indicates a very great amount of river erosion since the date of their formation.

Tertiary Rocks of Big Bar Creek and the Green Timber Plateau.

South branch of Big Bar Creek.

The northern part of the valley bordering the Marble Mountains on the west, contains the sources of the south branch of Big Bar Creek.

It is occupied by a long narrow strip of basalts, the surface of which generally slopes gradually to the westward from the base of the mountains. The whole valley is so much encumbered with drift material that little was seen of these basalts, but they appear to be of no great thickness. They probably connect with the basalts of the Green Timber plateau, round the eastern end of the Marble Mountains. Their southern termination, as shown on the map, is largely conjectural, on account of the complete mantle of drift in the vicinity. It is also possible that they may occur to some extent along the west side of the south branch of Big Bar Creek, though no evidence to this effect was obtained.

Kelley Creek.

Between the source of the south branch of Big Bar Creek and Kelley Lake, two streams from the eastward enter the valley separating the Marble Mountains from the Edge Hills. Near the mouth of each of these streams, basaltic boulders were observed to be very abundant, and it is possible that small basalt outliers may occur in these depressions, on the flanks of the Marble Mountains.

The Green Timber Plateau.

The Green Timber plateau, of which the southern part is contained in the present map-sheet, being crossed from Clinton northward by the old Cariboo wagon-road, is one of the best known features of this part of the province. To the eye, as viewed from any higher point, it is level and sea-like, but that part of it included in the map, really slopes gradually and somewhat irregularly from a height of 4500 or 5000 feet, near the north-eastern base of the Marble Mountains, to one of about 3000 feet near the North Branch of the Bonaparte River. The greater part of this eastern descent occurs, however, near the base of the Marble Mountains, the eastern portion of the plateau being not far from level. The whole plateau is heavily covered with drift deposits, but rock is occasionally seen in place, and where this does not occur, large masses or angular boulders of basalt of a single kind, are often found grouped together in such contiguity as to indicate that this rock is in place in the immediate vicinity. Along the southern edges of the plateau, near Clinton and on the Bonaparte Valley, sections of the basaltic rocks also occur, and there can be little doubt that the entire area of the plateau is underlain by rocks of this character, though it is possible that these may have been cut through to the older rocks below in some places. The source or sources of these great horizontal or nearly horizontal flows of basalt, have not been determined, but their general contemporaneity with the basalts of Big Bar Creek, those of the vicinity of Leon Creek and the very widely extended areas of basalt and basalt-breccia to the south and east of the Green Timber plateau, can scarcely be doubted.

Fly Creek.

On the lower part of Fly Creek, a tributary of the Bonaparte which forms a small cañon before reaching that river, good sections of basalt are seen, and rocks of the same character occupy the whole depth of the Bonaparte Valley to within about a mile of the mouth of the North Branch, where they are found to be underlain by greenish tuffaceous sandstones, dipping about N. 45° W. < 40°. The sandstones are imperfectly exposed and their thickness is not known. They rest upon greenish diabase, which is referred, though with doubt, to the Nicola formation, but this is soon replaced by granitic rocks which characterize the lower country about the forks of the Bonaparte.

Bonaparte east of Fly Creek.

From Fly Creek eastward, nearly to the mouth of the Chasm, the Bonaparte Valley is similarly characterized by basaltic rocks, sometimes forming more or less distinctly columnar flows, sometimes rough breccias arranged in thick beds. These rocks frequently form mural cliffs along the higher slopes of both sides of the valley. Half a mile above the mouth of the Chasm, a small projecting point of gray schistose rock occurs. This is overlain by a considerable thickness—probably several hundred feet—of soft, white and yellowish tuffaceous breccia, which extends to the Chasm and beyond it, forming cliffs characterized by fantastic, mural and columnar forms. The matrix is a pale-gray mortar-like material, and this is studded with fragments, sometimes as much as two or three yards in diameter, which are generally angular and are chiefly volcanic rocks of various kinds. The smaller fragments appear to be more varied in origin, and are often partly rounded.

Tuffaceous breccia.

The Chasm.

This breccia has evidently been deposited in water, and is fairly well stratified though the component beds are thick. At the mouth of the Chasm it overlies a mass of purplish decomposed porphyrite and is capped by basalts and basalt-breccias of the ordinary type. The remarkable cliffs of the upper parts of the Chasm, represent rocks which overlie the pale breccia. These are very well bedded, generally in layers not exceeding six feet in thickness, and most of the beds appear to represent volcanic muds or sands of a basaltic character rather than true eruptive basalts, though layers of the latter character also occur. The columnar appearance presented by the cliffs, is due chiefly to weathering along jointage planes and only in part to the development of a true basaltic structure. Bright yellow and red layers are conspicuous in the cliffs and the aspect of the whole is very picturesque and striking. A good general view of the Chasm, from above, is gained from a point on the Cariboo wagon-road near its bend. At this place, the basalt, in a borrow-pit on the road, includes

numerous cavities filled with crystalline chabazite. The whole thickness of the volcanic rocks cut through in the Chasm must be over 1000 feet.

The plateau area to the north of the main valley of the Bonaparte and east of the North Branch, must be regarded as a portion of the Green Timber plateau, cut off merely by the erosion of the valley of the North Branch. The basaltic rocks come down to the bottom of the valley near the outlet of Young Lake, where they are represented by brownish, compact and vesicular basalt flows. Elsewhere the lower slopes of the Bonaparte Valley, in this part of its length, are characterized by granitic rocks, which appear to directly underlie the basalts. Plateau east of North Branch.

Tertiary Rocks of the Bonaparte Plateau, the Arrowstone Hills and Adjacent Country.

The Bonaparte Plateau may be described as a southern extension of the Green Timber plateau, from which it is cut off only by the subsequently eroded valley of the Bonaparte. The basaltic rocks cut through by the Bonaparte Valley have already been noticed, and it is probable that the entire area of this plateau is characterized by similar rocks. It has been traversed only on the exploratory lines shown on the map, by Mr. McEvoy, who writes of it as follows: "Southward from the forks of the Bonaparte, the basalt begins at an elevation of 3400 feet, and continues on the line of route to Loon Lake valley. Along this valley, to the westward, and for two miles and a half along the north side of Loon Lake itself, is a blackish fine grained basalt, often amygdaloidal, containing chalcedony and other minerals. Further to the west, the lake-shore is composed of basaltic breccia and fine grained, dark-gray basalts showing well marked flow-structure." Bonaparte Plateau.

The Arrowstone Hills, stand in the centre of a wide and generally plateau-like area, which for purpose of description may be limited to the northward by the Loon Lake valley, to the south by part of the Thompson Valley and to the west and east respectively by the valleys of the Bonaparte and Deadman rivers. The profile of the central parts of this area, seen from almost any bearing, shows it to possess a depressed dome-like form, the highest part of which includes the blunt summits of the Arrowstone Hills, reaching elevations of about 5700 feet. The whole form of the surface has of course been affected to a very considerable extent by denudation, but its general aspect seems to indicate, that the higher region of the Arrowstone Hills may represent the source from which much of the volcanic material covering this tract of country welled up. Arrowstone Hills. General form.

Rocks largely basaltic.

A large part of this area is very inaccessible because of its thickly wooded character. It has, however, been traversed on several lines by Mr. McEvoy, from whose observations it would appear that probably eight-tenths of its entire surface is occupied by basaltic rocks, either in the form of flows or in that of basalt-breccias, often very uniform in composition and appearance for long distances. Volcanic rocks of other kinds observed, are chiefly those of the higher parts of the Arrowstone Hills and those found underlying the ordinary basaltic materials where these have been cut through. Thus, in respect to this area, attention has been chiefly directed to ascertaining the outlines of the Tertiary volcanic rocks as a whole, rather than to any detailed examination of different parts of the plateau.

Possibly older eruptions.

It is quite possible that some of the rocks met with, particularly those of parts of the Arrowstone Hills themselves, should be classed with the older Miocene eruptives, like those found in the Clear Mountains and on the Nicola Valley, but as there is no means of determining this point, it has been thought best to include the whole of the mass with the later eruptives, to which by far the greater part, at least, certainly belong.

Notes on routes traversed.

The subjoined notes by Mr. McEvoy, relate to the routes actually traversed by him and shown upon the map. "The southernmost main elevation of the Arrowstone Hills, lies between the two branches of Câche Creek and the sources of Scottie Creek. In ascending from the forks of Câche Creek, purplish porphyrite is found, and rocks of a somewhat similar character are abundant on this slope. In the higher part of the hills they become very hard and tough, and much resemble some rocks seen on the north slope of Mount Glossy. Some of these rocks are distinct augite-porphyrites. On the north side of this group of hills, which slopes down to Scottie Creek, there is an exposure of very fine-grained augite-porphyrite, resembling obsidian, associated with basalt*"

Obsidian-like rock.

The obsidian-like rock above mentioned, is very common in loose boulders and fragments everywhere in the vicinity of the Arrowstone Hills. It was formerly employed by the Indians for the manufacture of arrow- and spear-heads, and probably occurs in considerable volume in the higher parts of the Arrowstone Hills.

Hyalite.

"Crossing Scottie Creek and ascending the hill to the north, the country is deeply drift-covered. The top of the hill is generally composed of dark brownish basalt, often highly vesicular. On a summit one mile south of Hi-hium' Creek, this holds hyalite, both in the vesicles and between the layers of flow-structure. The extent of the area in

*Appendix I., No. 74.

which the hyalite was observed to occur, is about one mile by half a mile, and some very fine specimens of this mineral, now in the museum of the Geological Survey, were obtained."

"No exposures were found about the crossing of Hi-hium' Creek, but on the slopes of the hills to the north, vesicular basalt again occurs. The higher parts of these hills are composed of basaltic rocks* similar to those already noticed in connection with the southern summits of the Arrowstone Hills. No exposures were found on the north slope, in descending to Loon Lake, but the rocks are evidently basaltic."

The valley of the Deadman River, with a general course from north to south, connects the Bonaparte Valley with that of the Thompson, and forms the eastern boundary of the region now under description. "From the source of its north-western branch as far as the mouth of Criss Creek, a distance of more than twenty-two miles, it forms a deep narrow trough, which cuts through the Tertiary volcanic materials and exposes the underlying rocks of the Nicola formation nearly throughout, though in one or two places the Tertiary crosses the line of the valley. North of the mouth of Criss Creek and as far as Deadman Lake, soft white tuffaceous ash-rock is found exposed in vertical cliffs, with a maximum observed thickness of 500 feet, the bases of the cliffs being generally buried by slopes of talus. The talus seems in some places to cover a deposit of Tertiary conglomerate resembling that of Copper Creek, for between the mouths of Criss and Gorge creeks, numerous loose masses of such a rock were found. Overlying the tuffaceous beds are basaltic breccias, with a thickness of some 800 feet, and capping these, at the level of the plateau, are flows of brown basalt."

Deadman Valley.

Massive tuffaceous sandstones.

The tuffaceous rocks above referred to, are in some specimens almost entirely composed of fine-grained felspathic matter of volcanic origin, but they generally include a certain proportion of arkose material with angular or sub-angular quartz grains. In some specimens the quartz grains become very abundant and a large part of the whole mass appears to be of an arkose character, derived from the decomposition of granitic rocks.

Arkose material.

Along the west side of this area of plateau, the Tertiary rocks come down to the bottom of the Bonaparte at one place only, opposite the mouth of Hat Creek. They consist here of basalt-breccias and basalts. So far as ascertained, similar rocks appear to prevail in outcrops which occur high up on the sides of the valley. The Tertiary volcanic rocks outcropping on the south side, in the vicinity of the great trough now occupied by the Thompson River, have already been in part noticed in

Parts of Bonaparte and Thompson Valleys.

* Appendix I., No. 73.

the description of the general section from the Bonaparte to Copper Creek (pp. 217 B, 218 B). Along the north side of the Semlin Valley, the volcanic rocks of the plateau are broken off in bold escarpments and cliffs. These have not been examined in detail, but they include both basalts and other materials of a less basic character, all arranged in massive layers and weathering to reddish colours.

Near Eight-mile Creek.

The summit of the plateau to the west of Eight-mile Creek, in the angle between the Eight-mile Creek valley and Pass Valley, was found by Mr. McEvoy to be capped by dark-brown basalt containing very numerous crystals of magnetite, underlain by a volcanic breccia with a yellowish, earthy matrix. Near the mouth of the gorge of Eight-mile Creek, just above the wagon-road in the Thompson valley, a white, banded, felspathic rock, probably a trachyte, with very fine lamination produced by flow-structure, was noted by Mr. McEvoy. The rocks seen along the Pass Valley, are all referable to the Tertiary volcanic series. Basalt-breccias and breccias charged with fine-grained augite-porphyrites resembling obsidian, being the most abundant.

Connection with Savona Mountain.

Apart from the somewhat peculiar rocks of the higher portions of the Arrowstone Hills, the Tertiary volcanic materials of this plateau generally closely resemble those of Savona Mountain and the plateau attaching to it, from which they have indeed been divided only by the deeply excavated valley of the Thompson River.

Tertiary Rocks East of the Deadman Valley and North of Kamloops Lake.

Near Bonaparte Lake.

The Rim Hills, north of Bonaparte Lake, are capped by basalts in the manner shown on the map. These appear to rest directly on the granites of the region, but they have been laid down from bearings and distant views only.

The small outlier of Tertiary shown to occur to the north of the east end of Bonaparte Lake, was ascertained by Mr. McEvoy to consist of amygdaloidal basalt and brown dolerite.

The Kuk-waus′ Plateau, the Sil-whoi′-a-kun Plateau, the western part of the Tranquille Plateau and Red Plateau, together form portions of a single great area characterized by a wide spread of Tertiary volcanic rocks. This it will be convenient to consider briefly from north to south, in the order above indicated.

Kuk-waus′ Plateau.

The Kuk-waus′ Plateau, may be regarded, for purposes of description, as bounded on the south side by the upper part of the main stream of Deadman River and Hi-ak′-wa Lake. It has undoubtedly at one time

been entirely covered by horizontal flows, which have also, in all probability, extended across the hollow now occupied by Bonaparte Lake and connected, beyond the Bonaparte River, to the north-eastward, with the basalts of the Green Timber plateau. The surface had here, as elsewhere in this region, been worn down to an approximate equality in elevation before the date of the eruption of the basalts, the base of which is now found at a height of about 4500 feet on both sides of Bonaparte Lake, at about 4000 feet along the south side of the Bonaparte Valley near Young Lake, and at about 4600 feet near Granite and Hi-ak'-wa lakes.

Levels of base of basalts.

The rocks underlying the basalts of the Kuk-waus' Plateau, are generally granitic, but on the south side of the plateau older stratified rocks also occur. No evidence of the existence of any bedded Tertiary materials beneath the basalts, has been found in this region, and if any such occur they must be local and not of great thickness. The basalts of this plateau are generally gray or brownish in colour, so far as observed, and offer no points of particular interest. They are occasionally vesicular, but not often columnar, except toward the east end of the plateau, where this structure is more usual. Seen from Bonaparte Lake, they form flat cappings to the higher granitic hills, and as observed from the summit of Skoatl Point, the various, and now more or less disconnected remnants, of the basalt flows, run together in the distance to form an almost perfectly level horizon-line. The western part of the northern outline of the basalts of Kuk-waus' Plateau, as shown upon the map, must be regarded as approximately correct only. All this region is covered with fallen timber and is very difficult to traverse.

No sedimentary beds seen.

Character of basalt flows.

FIG. 6. SKOATL POINT FROM THE WEST, ABOUT A MILE DISTANT.

Skoatl Point, is a small volcanic outlier standing near the eastern margin of the Kuk-waus' Plateau, from which the basaltic flows, doubtless at one time surrounding it, have been stripped away, leaving a tract of undulating hills composed of granite and old altered rocks, now

Skoatl Point.

more or less covered with drift deposits and dotted with lakes. From this, Skoatl rises very abruptly, with a steep conical form—somewhat narrower in its north-and-south than its east-and-west diameter. It affords a magnificent view of the frayed eastern edge of the basaltic plateau for many miles, and is itself a prominent and easily recognized point, which may be picked up from the summits of the higher mountains often at a distance of fifty miles or more. It is composed of a somewhat coarse-textured, dark-gray olivine-basalt, with a finely developed columnar structure.* The columns average about a yard in diameter, and are curved in several directions, but with a general tendency to meet toward the apex of the hill. Those on the west side run from base to summit with a gentle sweep. There is every reason to believe that Skoatl represents the plug of an old vent, from which much of the basaltic material of the vicinity may have flowed out.

Sil-whoi′-a-kun plateau.

The name Sil-whoi′-a-kun, though more restricted in its application by the Indians, may be employed in the present connection to designate all that part of the plateau to the south of that last described and to the north of Tranquille Lake. This is almost entirely covered with basaltic rocks. The rocks of its western edge, as they occur along the Deadman River, have already been noticed (p. 221 B). In the part of the region drained by Criss Creek, and along the upper valley of that creek, the rocks seen are all ordinary gray or brown basalts, often forming several superposed flows and occasionally columnar.

Near Caribou Lake.

In the valley in which Caribou and Tsin-tsoon′-ko lakes lie, the sheet of volcanic rocks has been cut through locally, exposing an isolated area of Palæozoic rocks and granite. The basalts found in this vicinity are gray and blackish, not often vesicular, and seldom distinctly columnar.† Poison Hill, is a rather prominent bold spur of the eastern edge of this part of the basaltic area, rising nearly 300 feet above the low land at its base. It is chiefly composed of rudely columnar basalt, more or less amygdaloidal, with the vesicles filled with zeolitic minerals, but is capped by a similar blackish basalt with a laminated appearance due to nearly horizontal flow-structure.

Dome-like form of plateau.

As seen from a distance, particularly in a general view obtained from the summit of Pavilion Mountain, the whole of this part of the plateau rises gradually to a wide dome-like form, of which the highest part is in the vicinity of Porcupine Ridge, in a manner highly suggestive of the belief that a great part of the basalts of the surrounding flowed out from this as a centre. (Compare p. 219 B.)

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* Appendix I., No. 78. †Appendix I., No. 77.

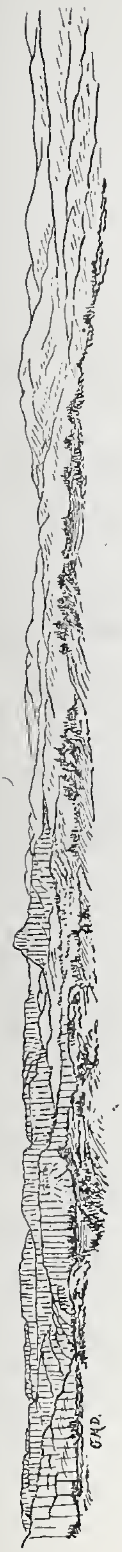

FIG. 7.—EASTERN ESCARPMENT OF BASALTIC ROCKS.
As seen looking northward from Poison Hill. Vertical shading indicates the basaltic rocks.

Levels of base of basalt.

The highest portion of the base of the basaltic flows is likewise found near Porcupine Ridge and Basalt Point of the map, at elevations of 5490 and 5400 feet respectively. From this vicinity, the level of the base of the volcanic materials declines northward to that already referred to near Hi-ak′-wa and Granite lakes, westward to about 3000 feet on the lower part of Criss Creek, and southward to even lower levels in the vicinity of Kamloops Lake. No trace of Tertiary sediments underlying the basaltic flows was found in this region, except as already noted along the Deadman River at its western end, but it is seldom that the exposures are so good as to enable it to be stated definitely that beds of this kind of small thickness may not occur.

Porcupine Ridge.

The most elevated part of the entire Sil-whoi′-a-kun Plateau is that at and near Porcupine Ridge, where the height attained is about 6000 feet. The summit of Porcupine Ridge, though broken by numerous minor irregularities, is in the main nearly horizontal. To the south it is broken off abruptly toward the deep valley in which Tranquille Lake lies. The rocks composing the ridge are chiefly olivine-basalts of dark colours, verging on black, and often lumpy and irregular in consequence of a fragmental or concretionary structure—probably the latter.* Some ordinary gray basalt was also found, and in two or three places areas of coarse brownish hornblende andesite with a lamination produced by flow-structure which dips at various angles irregularly.† The best marked occurrence of this rock is that forming a partly detached hill on

* See Appendix I., No. 63.
† See Appendix I., No. 64.

the south slope, and this, as seen from the opposite side of the valley, much resembles the filling of an old vent or fissure of eruption. On the western flanks of the more massive rocks comprising the ridge itself, basaltic strata, often columnar, are seen, from the south, to rest upon the rocks of the ridge and to slope away from them as a centre.

A probable vent.

These and other circumstances tend to show that Porcupine Ridge marks the site of one of the more important local sources of the great basaltic eruptions of the later Miocene.

At the junction of Criss Creek with the Deadman River, the plateau runs out in a narrow and remarkably bold point which may be called Split Rock. This is chiefly composed of rough basalt-breccia and is traversed in one place by a deep open fissure with vertical walls.

Tranquille Plateau and vicinity.

To the south of the region above described, is a large area of plateau chiefly drained by branches of the Tranquille River, of which the volcanic rocks of the Tertiary cover the greater part, as far south as Kamloops Lake. To the south of Criss Creek and west of Porcupine Ridge, a considerable district of this part of the plateau has not been examined on the ground. It is densely wooded or covered with fallen trees, but its contour, as seen from various points of view, and the margins of the volcanic rocks which have been defined, indicate that it is probably occupied in the main by ordinary basalts. The great quantity of large and small boulders of olivine-basalt* met with in the valley of the Tranquille some miles above the fall, however, shows that a considerable area of rocks of this character must occur to the west of Porcupine Ridge.

Near Lower Criss Creek.

The summit of the plateau in the angle between Criss Creek and the Deadman River, on the east, at elevations of 3000 to 3500 feet, is composed of blackish, basaltic rocks, sometimes very rich in olivine, but is so much covered with drift that they are seldom seen in place and their precise extent, particularly to the eastward, remains doubtful. After crossing the continuation of the cherty conglomerates of Copper Creek, the country, to the Tranquille Valley, is chiefly characterized by basalt flows, both on the line of traverse by way of the Red Lakes and on that from the head of Copper Creek, but on both routes much of the ground is covered by drift.

Upper Tranquille Valley.

In the Tranquille Valley, a couple of miles above the fall, a white dacite† was found to form the lower slopes for 200 to 300 feet above the level of the stream. Overlying this are basalts and basalt-breccias to the level of the plateau on both sides. Following the valley down,

*Appendix I., No. 76. †Appendix I., No. 70.

the dacite appears to extend nearly as far as the fall, but with this exception, the rocks seen on both sides are almost entirely basaltic, and chiefly consist of basalt-breccias, to the mouth of Watching Creek. The beds composing these are more or less lenticular, but the aggregate thickness is well preserved. They are nearly horizontal and frequently produce steep scarps and cliffs, which resemble both in their appearance and composition those met with to the north of Battle Bluff (p. 172 B) of which the beds seen here are the continuation. Near the mouth of the stream which comes in from the north side of Mara Hill, these rocks are underlain by the soft, yellowish, tuffaceous agglomerates, forming part of the subdivision designated as No. 6 in the Kamloops Lake section (p. 165 B).

Middle Fork and Watching Creek.

On the trail which runs eastward from the main valley of the Tranquille, crossing the Middle Fork and Watching Creek some distance above their confluence, similar basalts and basalt-breccias are seen ; but where this trail crosses the Middle Fork, exposures of soft, yellowish, tuffaceous agglomerates, charged with fragments of brittle tachylite (?) and evidently representing those above referred to subdivision No. 6, are met with.

Plateau south of Tranquille Lake.

From this point, a traverse was made up the Middle Fork and to the south side of Tranquille Lake. The summit of the plateau here has an elevation of from 4500 to 5000 feet, and is more varied in the detail of its topography than might be supposed from distant views of it. The basaltic flows of which its whole upper surface appears to be composed, frequently form low plateau-like hills with steep broken edges. The rocks seen were basalts and olivine-basalts.*

Tertiary base sloping toward Kamloops Lake.

Along the upper part of Watching Creek, the volcanic capping of the plateau appears to have been entirely removed by subsequent processes of erosion, and the stream flows over surfaces of the old Palæozoic rocks. From high points on its eastern side, it is evident that the base of the Tertiary volcanic rocks slopes gradually southward, and at about two miles above the entrance of the valley in which Pass Lake lies, they come down to the bottom of the Watching Creek valley. Below this point, Watching Creek, and the Tranquille River into which it flows, nowhere cut down to the base of the Tertiary ; and the comparatively thin covering of basaltic materials which occupies much of the plateau further to the north, in the vicinity of Kamloops Lake is increased till it forms the series which has already been described in connection with the section in the vicinity of this lake (p. 173 B). It is thus evident, that near the present position of the lake, an original

*Appendix I., No. 75.

An original depression.

depression existed at the time in which the Tertiary sediments and volcanic materials were accumulated. This conclusion, resulting from the constitution and thickness of the Tertiary rocks as a whole, is independent of any later change in relative elevations which may have tended still further to depress the country in the vicinity of the lakes. To the east of the lower part of Watching Creek, the level of the surface of the old rocks upon which the Tertiary was deposited, also rises rapidly, as will be apparent on comparing the level of the northern part of the Garde Lafferty (with its small outlying patches of conglomerates) with that of the bottom of the lower part of the Tranquille Valley.

Hill of pikrite-porphyrite.

The hill to the east of Watching Creek and north of Pass Lake, which was ascended and examined, is chiefly composed of pikrite-porphyrites, blackish, greenish and greenish-gray in colour, and presenting a peculiar spotted appearance. These are capped by blackish basaltic rocks. Opax Hill was not ascended, but it appears to be composed chiefly of basaltic materials about its summit, while rocks of the same character as those just noted may probably occur in its lower portions.

The small detached area of Tertiary volcanic rocks shown to the east of Watching Creek, occurs in a tract of country rendered almost impassable by windfall. It was not actually reached, but from the character of the numerous loose masses found to the south of it, is believed to consist entirely of basaltic rocks.

Tertiary Outliers in the Vicinity of the North Thompson River.

Indian reservation on North Thompson.

Basin of sedimentary rocks.

The most important of these detached areas of Tertiary rocks, is that near the Indian village and reservation at the extreme north-east angle of the map. This was particularly examined in 1877, because of the occurrence of coal in it. The Tertiary rocks here occupy a portion of the trough of the North Thompson, and are bounded on both sides by the old rocks of the higher hills. The amount of drift in this part of the valley is very great. On the east side of the river, a few exposures occur of sandstones and shales, particularly along the small stream named Coal Brook, but it is impossible precisely to define the area occupied by these rocks, which can be approximated to only on the assumption that they characterize the lower parts of the valley where the old rocks are not seen. On this assumption, the whole length of the Tertiary area to the east of the river cannot exceed five miles, while it may be much less. On the west side of the river, the only Tertiary rocks seen are gray and brown basalts, which occur quite down to the river-level nearly opposite the Indian village, and were also found on

Its area.

the lower slopes of the hills on that side to a maximum height of 620 feet above the river.

The sedimentary beds in which the coal occurs, may of course underlie some part of the area in which only basalts are seen at the surface. A trifling amount of exploratory work has been done in recent years in the immediate vicinity of the coal outcrops at Coal Creek, but no addition has resulted from it to our general knowledge of the section, and it is improbable that any material addition to this knowledge will occur till boring operations shall have been undertaken. The sandstones and shales show no traces of volcanic material in their constituants, and it is probable that they represent an area of the Coldwater series of the Tertiary, as previously defined. The basalts are probably referable to a much later date.

Occurrence coal.

Boring necessary.

The following description and section of the beds is quoted from my report of 1877 (pp. 113 B-114 B.)

Description of the measures.

"The area of this outlier, in so far as it can be defined by the section on the east bank of the river, is not great. It rests on the older crystalline rocks, forming a ridge about 600 feet high along the base of the tier of mountains which, rising to a height of 2000 to 3000 feet above the river, here forms the border of the valley. The length of the ridge is about two and a half miles, and it is where the little stream called Coal Brook cuts through it, that the Tertiary rocks are exposed, by the removal of the thick covering of boulder-clay and drift, which elsewhere shrouds it. The beds appear to form a syncline, nearly parallel in its main direction with the trough of the valley.

"The following section, in descending order, includes nearly all the beds seen in the brook channel. Some layers were measured, others estimated by the eye only:—

Section.

	Feet.	In.
1. Sandstone, soft. . . . . . at least	2	0
2. Carbonaceous shale	0	6
3. Shale and sandstone	3	0
4. *Coal*, shaly. . . . . . about	1	3
5. Hard clay	0	6
6. Soft shale	1	3
7. Gray, fine shale, with fossil leaves	2	0
8. Coarse- and fine-grained sandstone	15	0
9. Hard, fine, gray clays	1	0
10. (Concealed)	10	0
11. Sandstone	2	0
12. Gray shales	3	0
13. Sandstone	2	0

		Feet.	In.
14.	Soft, gray shale	1	5
15.	*Coal*	1	2
16.	Shale	0	2
17.	Sandstone and shaly sandstones	9	0
18.	*Coal* } irregular	1	5
19.	Black shale } irregular	0	8
20.	Gray, crumbling sandstone	4	0
21.	Carbonaceous shale ....1 in. to	0	4
22.	Rusty, nodular sandstone	1	8
23.	Soft sandstone in thin layers	8	0
24.	Concealed ....15 feet to	20	0
25.	Sandstone	4	0
26.	Black shales	0	6
27.	Sandstone	0	10
28.	Shales, more or less carbonaceous, with a little coal	4	0
29.	Ironstone, nodular	0	3
30.	Thin-bedded clays, grayish and brownish	2	8
31.	Gray sandstone, generally coarse and rather soft	10	4
32.	*Coal*, shaly	0	2
33.	Brownish, sandy clays	6	9
34.	Thin-bedded sandy clays, rather hard ....about	20	0
35.	Coarse, pebbly sandstone ....about	8	0
36.	Brownish-gray sandy clay, at base	..	..
		148	1

Dips

"At the base, the beds dip at an angle of 12°, further up at 15°, and again begin to dip at a lower angle at the summit. The direction of dip varies from N. 56° E. to N. 26° E. The lowest beds are first met with in ascending the brook. Beyond the highest represented in the above detailed section, a considerable gap occurs, in which the banks show no exposures. When next seen, the beds are poorly exposed, but one bank shows about twenty feet of sandstones and shales like those before met with, and includes two small seams of coal, the lower seven inches, the upper nine inches in thickness. These beds are doubtless the highest found in this locality.

"It would appear, however, that in the sections, but a small portion of the entire thickness of Tertiary beds represented at this place, is seen. Their general character is much like that of those of other localities in the southern part of the province, the sandstones holding, perhaps, more coarse pebbly material than usual. Notwithstanding this, however, there is no appearance of tumultuous deposit, and the coal-seams, though thin, show considerable regularity. The coal-bearing character of the formation appears to persist throughout the section, and a further examination by boring may at some time become desirable.

Site for boring.

The best locality for a bore-hole would probably be in the valley of the brook, at the lowest beds of the section."

In 1892, Mr. McEvoy revisited this locality and gives the following note concerning it :* Later work on coal.

"While in the neighbourhood an opportunity was afforded of visiting the coal mine on the North Thompson Indian Reserve. A tunnel running northward from the creek bed showed the following section :—

Coal	6 inches.
Sandstones	2 feet (variable.)
Coal	9 inches.
Sandstone	6 "
Coal	18 "

"Besides these an underlying seam of coal is reported."

The quality of the coal found here is good, and if thicker seams can be found, it would possess an immediate economic importance; on proximate analysis, it yielded the following results to Dr. B. J. Harrington :† Quality of the coal.

	Fast Coking.	Slow Coking.
Hygroscopic water	2·22	2·22
Volatile combustible matter	38·10	32·05
Fixed carbon	46·76	52·81
Ash	12·92	12·92
	100·00	100·00
Coke	59·68	65·73
Ratio of volatile to fixed combustible,	1 : 1·23	1 : 1·65

"Fast coking gave a bright and firm coke, which on burning away left a reddish-white ash. By slow coking the powder was agglutinated only in the bottom of the crucible."

A few fossil plants obtained from the above section in 1877, are thus described by Sir J. Wm. Dawson :‡ "The leaves from this place, in a matrix of gray arenaceous shale, are almost exclusively poplars, referable to *Populus arctica*, *P. genatrix*, Newberry, and another species. With these is a species of *Rhus*, allied to *R. rosaefolia*, of Lesquereux." Fossil plants.

The Tertiary outlier of Skull Hill, further down the North Thompson, consists, apparently, wholly of basalts and basalt-breccias, which seem to have locally a thickness of 500 feet or more and may rest directly upon the older rocks. Skull Hill outlier.

* Summary Report of the Geological Survey Department, 1892, p. 10.
† Report of Progress, Geol. Surv. Can., 1876-77, p. 467.
‡ Trans. Royal Soc., Can., vol. I., sect. IV., p. 34.

Other small outliers.

The next small outlier to the southward, on the opposite or east bank of the river, consists of blackish fine-grained basalt. On the same side of the river, four miles still further south and near Sullivan Creek, a very small outlier of basalt was seen from below to be patched upon the granitic rocks there prevalent. Its precise outlines to the east and north have not been fixed.

Dome Hills.

A somewhat larger patch of Tertiary rocks, appears to the south of Edwards Creek on the northern slope of the Dome Hills. This consists of several superposed flows of basalt, rich in olivine. It is often vesicular, holding chalcedony, or showing small quartz-lined cavities. Its eastern outcrop is rather obscure, but to the west it breaks off in an escarpment, along the base of which several springs rise. The occurrence of those springs may indicate the existence of some permeable underlying sedimentary materials, but no exposures of such rocks were found.

Tertiary Rocks to the South of Kamloops.

Basaltic outliers near Kamloops.

The Tertiary rocks of this vicinity have already been noticed, as far as the coal locality marked on the map (p. 168 B). Immediately to the south of this, in the vicinity of Peterson Creek, the granitoid rocks are capped by several small basaltic outliers which are generally situated near the 3000-foot contour-line, but are not strictly confined to any particular level, resting as they do upon sloping surfaces of the older rocks. The apparent low dips by which they are affected, may probably represent the original inclination of the flows. At the road-crossing of Peterson Creek, these rocks are found at a rather lower level than usual and form a somewhat prominent little hill. The basalts are generally blackish or gray, and of the ordinary type. Their thickness is not great, and they appear to rest directly upon the granitoid rocks, and to lie altogether beyond the margin of the old depression in which the water-bedded materials holding the coal have been laid down.

Area between Separation Lake and Stump Lake.

A much more important Tertiary area, with which the outliers just noticed have evidently at one time been continuous, is that which runs southward from the vicinity of Separation Lake to the head of Stump Lake, with a length of thirteen miles and a half and a maximum breadth of about six miles. The northern part of this area appears to consist entirely of basaltic flows of the usual character. The eastern edge of the volcanic rocks generally forms a well-marked escarpment at an elevation of about 3000 feet, overlooking the long

valley in which Shumway and Trapp lakes are situated, but to the westward, the level of the plateau rises gradually, though irregularly, till the basalt rocks are found in some places at heights exceeding 4000 feet. In this region, to the north of the head of Moore Creek, the edge of the basalts often ceases to be marked by a distinct escarpment, and as the country here becomes thickly wooded their boundary is drawn with less precision than elsewhere.

Underlying pale felspathic rocks.

The southern part of the area is characterized by a greater thickness, as well as by a somewhat greater diversity in the character of its volcanic rocks, for while basalt flows still occupy most of the surface, a series of pale felspathic rocks, which here comes in beneath them, is found in a number of places. Rocks of this character were seen further north, about half a mile west of the head of Brigade Lake, where they are represented by a fine-grained purple-gray material now much silicified, shattered and very hard. They are also abundant on the lower part of Dropping-water Creek and about the south end of Napier Lake, where the most characteristic form is a white quartz-mica-porphyrite, which occasionally becomes a fine-grained felspathic rock without defined macroscopic characters.

Overlying basalt-breccias.

These rocks are here probably 200 feet in thickness or more, and to the west of Napier Lake, and near the north end of Stump Lake, they appear to rest directly upon the irregular surface of the Nicola formation. About the south end of Napier Lake, they are overlain by massive basalt-breccias with at least a similar thickness, which in some places, by the rounded character of the basalt fragments, seem to indicate a certain amount of contemporaneous water-action. These are seen to occupy a well marked syncline which runs in a north-westerly direction from the south end of Napier Lake, and the series is probably affected by several low flexures of this character in that vicinity. The basalt flows previously described are believed to be later in date than the basalt-breccias.

Dropping-water Creek.

On Dropping-water Creek, about two miles above the road-crossing, on the west side of the valley, pale brownish and gray felspathic rocks of the underlying series stand out in a rather remarkable cliff, which is traversed by several great open fissures. Small irregular cavities in this rock are filled with opaline silica, which in some specimens approaches the condition of precious opal so closely, as to warrant the conjecture that this mineral may yet be found in the vicinity. Similar occurrences of opaline silica were noted in other exposures of the pale-coloured rocks in this particular region.

Fossil plants.

Also on Dropping-water Creek, between the point last mentioned and the road-crossing, fragments of a fine-grained, silicified, shaly rock are abundant, in which some plant remains occur together with a few poorly preserved specimens of insects. These peculiar rocks were scarcely seen in place, but must underlie some part of the valley in this vicinity, and in all probability are to be found beneath the pale felspathic materials. Their position is approximately indicated on the map.

The following species of plants have been recognized in the collection from this place, by Sir J. Wm. Dawson and Professor D. P. Penhallow* :—

Azollophyllum primævum, Pen.; *Pinus trunculus*, Dn.; *Acerites negundifolia*, Dn.; *Carpinus grandis*, Ung.; *Carpolites dentatus*, Pen.; *Sequoia*, Sp.; *Glyptostrobus*, Sp.; *Acer* (Fruit).

At McDonald's, between Trapp and Napier lakes, twenty feet or more of sedimentary material is actually seen beneath the basalt-breccia. This consists below of gray arkose sandstone, above of brown earthy material with seams of coaly matter two or three inches in thickness.

Eastward of Stump Lake, the basalt-breccias of Dropping-water Creek continue for two or three miles, beyond which they are covered by black and brown basalt. The basalt here reaches an altitude of 4200 feet.

Possible occurrence of coal.

It may be added, that the circumstances connected with the southern part of this area of the Tertiary, appear to render it probable that some thickness of ordinary sedimentary beds may exist beneath its volcanic rocks, filling an original lake-depression in the old surface. In addition to the silicified plant-bearing beds just referred to, fragments of gray, sandy shale of Tertiary age, have been found in the valley of Dropping-water Creek, and it is not impossible that deposits of coal may exist there. This can, however, be tested only by means of boring operations, and if at any time such a test should be applied, the most promising locality seems to be that about two miles above the road-crossing of the creek.

Age of plant-bearing beds.

The stratigraphical position of the plant-bearing beds at this place is uncertain, the fossils being too few to determine this, and no other definite evidence being available. It is probable, however, that they are on or near the horizon of the Tranquille beds.

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*Trans. Royal Soc. Can., vol. VII., sec. IV., p. 75. The specimens are those there described as coming from the vicinity of Stump Lake.

The area of Tertiary rocks shown at the edge of the map, to the east of Napier Lake, appears to consist entirely of basalts.

Near Trapp Lake, where massive dioritic rocks are immediately overlain by those of the Tertiary volcanic series, the former are frequently decomposed and soft, the felspar being more or less completely kaolinized and the hornblende replaced by chloritic or talcose minerals. On the east side of Napier Lake, the Nicola rocks immediately below those of the Tertiary, are decomposed and reddened, and often highly charged with iron pyrites; while at the north-east angle of Stump Lake, the older diabases are very much shattered and dolomitized. At the last-mentioned place, the alteration produced in the appearance of the older rocks is so considerable that the line between these and the Tertiary volcanic rocks was drawn with some difficulty, and it is probable that small areas of dolomitized sandstones like those previously described on the Nicola Valley (p. 195 B), may here, though in a more or less comminuted state, still rest upon the old broken surface. This dolomitization of the lowest beds of the Tertiary has been noted in several places where these rest directly upon the old surface.

Rocks immediately below the Tertiary.

To the north of Trout Lake, another small area of basalt was found. This forms escarpments toward Trout Lake and also on the hills to the south of Stake Lake. It is believed to be entirely separated by erosion from the larger basaltic area to the eastward, but this is not quite certain.

Near Trout Lake.

To the south-west of Trout Lake, at an elevation somewhat greater than the last, a small patch of black basalt, containing some granitic fragments and showing flow-structure, was found by Mr. McEvoy.

In the upper part of the Meadow Creek valley, about midway between Trout Lake and Greenstone Creek, hard, white, gritty, calcareous clays are seen in several places, which may possibly be of preglacial age, and if so would be referable to some late stage of the Tertiary. These clays must in any case be of small thickness and cannot continuously occupy any considerable area. It is presumed that they are in reality a post-glacial lake deposit, and no attempt has been made to indicate them on the map.

Meadow Creek clays.

Tertiary Rocks on the Upper Part of Guichon Creek and thence to Ashcroft.

The northern edge of the principal area of Tertiary rocks here referred to, of which Savona Mountain is a part, has already been noticed in connection with the sections near Kamloops Lake (p. 172 B).

Upper Guichon Creek.

The outline of the south-eastern part of this area, as shown on the map, must be considered as an approximate one, for the whole of this country is so heavily covered with drift deposits that outcrops are seldom found. The outline given to the Tertiary volcanic rocks is thus largely based on the contour of the surface, taken in connection with the distribution and abundance of large blocks and boulders of these rocks. The exact point at which the line crosses Guichon Creek here, is, however, particularly indeterminate.

Tuffaceous strata.

On the upper part of Guichon Creek, west of Toon-kwa Lake, low exposures were found of soft tuffaceous rocks, whitish and yellowish, resembling those described on the Deadman River (p. 221 B). These are supposed to underlie the basalts which elsewhere appear to characterize the whole tract drained by the northern sources of Guichon Creek, and are often extremely abundant in the form of loose masses and boulders. These generally present nothing unusual in their appearance, but are of brownish or gray colour, and not infrequently vesicular. The southern extremity of these rocks, north of the mouth of Meadow Creek, consists of olivine-basalt. Further south, to the east of the upper end of Mamit Lake, while the rocks actually seen appear to belong to the Nicola formation, some specimens of a material rich in fresh olivine and much resembling a Tertiary rock, have been collected. It is, therefore, possible that a Tertiary outlier may occur near here, and in fact, not improbable that several small patches of Tertiary volcanic rocks may yet be proved to exist in the country to the north-eastward of Mamit Lake and between the lake and the south side of Meadow Creek. The volcanic rocks of the Nicola formation are themselves here so little altered, that in hand specimens it is not always possible to distinguish them from those of the Tertiary.

Meadow Creek and Mamit Lake.

To the west of Mamit Lake, a small patch of Tertiary volcanic rock was found by Mr. Amos Bowman. It forms a perfectly flat little elevation, the limits of which have been fixed by distant views and bearings only.

Conglomerate boulders.

It may be added, that the occurrence of loose pieces of conglomerate resembling that of the Coldwater series, in the valley of Guichon Creek above the mouth of Meadow Creek, suggests the possible existence of outcrops of this character to the north-westward, in the drainage-basin of the stream. It may well be, however, that these have been carried southward during the glacial period from the conglomerate area to the west of Savona Mountain, or even from that of the vicinity of Copper Creek.

Forge Mountain and the hills attaching to it on the west, are chiefly capped by basaltic rocks, nearly horizontal, but varying slightly in the level of their base from place to place. Toward Mount Glossy, the base-level of the basalts rises very considerably. The summit of Forge Mountain itself, was found by Mr. McEvoy to be largely, perhaps entirely, composed of a gray glassy basalt, containing fragments of granite and other older rocks. Cinder Hill is capped by basalts and basalt-breccias. Forge Mountain.

The volcanic rocks on and about Mount Glossy, are chiefly brown and gray basalts, often vesicular and occasionally brecciated. Between Mount Glossy and Barnes Creek, the rocks met with are somewhat more varied, comprising basalts, red porous eruptives without macroscopic characters and gray tuffs. On the north side of Barnes Creek, similar materials are found, with the addition in one place of a pikrite-porphyrite,* and at the base of the section of a small thickness (observed by Mr. McEvoy) of soft basaltic tuff. Mount Glossy and Barnes Creek.

The detached area of Tertiary volcanic rocks that overlies the Cretaceous to the west of Barnes Lake, near Ashcroft, is a peculiar mass of mica-porphyrite, very homogeneous in its general character, but varying a little in appearance and hardness from place to place. It forms a rather prominent low hill on the side of the wide valley, and, as viewed from a distance, shows an appearance of massive bedding parallel to the general slope of the hill, indicating the existence of a pre-Tertiary depression near that now occupied by the river. That this rock here represents an outlier of a once more extensive flow, is shown by the fact that, a couple of miles further south, a narrow selvage of the same material† is found on the hillside, resting upon the Mica-porphyrite near Ashcroft.

FIG. 8. TERTIARY OUTLIER SOUTH-EAST OF BLACK CAÑON.

a. Cretaceous. *b*. Mica-porphyrite. *c*. Basaltic flow, separated from the last by a period of denudation.

sloping and denuded edges of the Cretaceous rocks and capped by a horizontal bed of columnar basalt. The mica-porphyrite is here Its relation to the basalts.

* Appendix I., No. 65. † Appendix I., No. 44.

affected by a well marked flow-structure on a small scale, parallel to the inclined surface upon which it lies, and its upper surface has been levellèd off by denudation between the time of its eruption and that of the basalt. Another small occurrence of the same rock, was found at the south edge of the Cretaceous, about a mile back from the river, but this is in all probability merely a dyke.

Plutonic Rocks.

Granitic rocks of Coast Ranges.

The granitic rocks of the Coast Ranges, to the west of the Fraser, may be characterized briefly as a group, and require no detailed notice. They consist almost exclusively of gray granites of medium coarseness of grain, passing, in their composition, from biotite-granite through biotite-hornblende-granite, to forms in which hornblende preponderates, and which may be named hornblende-biotite-granites. The biotite-granites are the most abundant, and those in which hornblende is largely represented are not found to characterize large areas.

Their character.

Many local variations in texture are of course found, but on the whole, these granites are very uniform in character. They seldom weather rusty, while the schistose rocks associated with them almost always do so, and thus the massive granites are pretty easily distinguished, even at a considerable distance. The outlines given to the granitic areas in the Coast Ranges, depend largely on such definition, resulting from examinations and sketches made from the several high points which were ascended. The actual forms of the mountains are often largely dependent on the nature and direction of the jointage planes, by which the granites are affected in an unequal degree in various places. About Kl-ow-a Mountain, the jointage was noted to be particularly bold. Pegmatite veins also abound in some localities, and in other places the granites are found to be cut by numerous dykes, of which the more characteristic appear to be divisible into two classes, viz., gray dykes consisting of quartz-mica-porphyrite or of mica-porphyrite and dark brownish or black, basic dykes.* Dykes of the last-named character, were observed in places near to the summit of Stein Mountain, to have assumed a foliated character as a result of subsequent pressure, becoming amphibolites. Both classes of dykes also cut the schistose rocks associated with the granites.

Dykes.

Foliated granites.

The granitic rocks are frequently more or less foliated in their structure, passing into forms which may be called imperfect gneisses, but every gradation is found, in some places, between these and the massive

*Appendix I., Nos. 93, 94, 95.

granites, from which they appear in most cases to have been produced by pressure. Such rocks are most abundant, as a rule, near the contact of the granites with the distinctly bedded Palæozoic strata, which in some places occur as isolated infolds in the granites ; and it is probable in other cases where well foliated granites are met with, that the upper part of a compressed syncline, which has originally included Palæozoic rocks, has since been removed by denudation.

Associated metamorphic rocks.

It is not always possible, however, to separate the highly altered bedded rocks, where these have passed into crystalline schists, from the associated materials which are believed to represent foliated granites. In these cases a separate colour appears on the map, but this must be understood to indicate merely such doubtful rocks, and not to represent a separate formation. It will also be understood, that the outlines of these gneissic or foliated bands are necessarily indeterminate, and that in many cases the distinctive colour is employed rather to indicate the existence of such rocks than to define their actual extent. These remarks apply to the Botanie, Scarped and Lytton Mountains as well as to those of the Coast Ranges.

Probably not Archæan rocks.

An examination of some limited areas, might easily lead to the belief that schistose and foliated rocks of the kind above described, constituted representatives of an Archæan series, and it is of course possible that remnants of such a series may exist here ; but there is, in my opinion, no sufficient evidences for such a conclusion in this particular region. In the Shuswap series of the Selkirk and Gold ranges, the circumstances are different, for there, rocks similarly crystalline in character are found unconformably beneath Cambrian strata and are interbedded with limestones and quartzites.

The following notes on rocks of the character above referred to, in the Coast Ranges, may be added here :—

Near Kl-ow-a Mountain.

Near Kl-ow-a Mountain, and just beyond the southern edge of the map, a narrow zone of blackish and gray micaceous-schist was found, and there may be more than one of the same kind in this vicinity. That examined was scarcely more than quarter of a mile in width. These rocks have somewhat the aspect of highly altered argillites.

Stein Mountain

The high ridge which separates Stein Mountain from the Fraser Valley, is largely composed of rocks showing more or less gneissic structure. Most of these are pretty evidently foliated granites, but there are also some fine-grained micaceous schists, which may be of different origin.

Si-whe' Creek.

Two small areas crossed by Mr. McEvoy on Si-whe' Creek, consist chiefly of finely laminated, fine-grained, greenish actinolite-schist, and

of dark-gray micaceous schist, all much twisted and intersected by granite dykes. Parts at least of these rocks probably represent materials originally bedded.

Lytton Mountains.

The Lytton Mountains, with the southern part of the Scarped Mountains and Botanie Mountain, are separated from the Coast Ranges by a narrow belt only of stratified rocks. The crystalline rocks of these mountains may therefore be considered as practically connecting with those of the Coast Ranges.

Lytton Mountains, consist chiefly of greenish-gray and pale-gray granite, generally hornblende-biotite-granite, in which, in many places, the hornblende much preponderates. These rocks are cut by numerous jointage planes, which give rise, in the rather flat upper levels of the mountains, to roughly hummocky forms. Near the south line of the map, most of the granites appear to weather easily, and in some places produce yellowish rubbly slopes of débris. Along the Thompson, on the north base of these mountains, numerous veins of pegmatite cut the granites. Most of the granites are here quite massive, but several narrow belts or tongues of gneissic rocks, with gray or green hornblendic or micaceous schists were noticed. In the eastern part of the mountains, these run in bearings nearly east-and-west, but toward the Fraser River, they assume the more usual north-northwesterly trend. Some of these almost certainly represent much-altered stratified rocks. They are always greatly shattered and weather to rusty colours.

Scarped Mountains.

On the opposite or north side of the Thompson, in the southern part of the Scarped Mountains, the greatest development of gneissic rocks, and that which most closely resembles some part of an ancient crystalline-schist formation, occurs. The bedding appears to be very regular upon the large scale, the dips being northerly at moderate angles, and a very considerable thickness of such rocks is shown in the bare slopes and cliffs which face toward the river. Numerous dykes, many of them doubtless of Tertiary age, run across the face of the cliffs. The rocks themselves include hornblendic and biotitic gneisses, quartz-mica-schists, etc.

Pegmatite veins.

On the west of these exposures, near the mouth of Botanie Creek, is a remarkably sharp crest or ridge, composed of granitic rocks, and cut in all directions by a network of pink pegmatite veins, like those noted in the northern base of the Lytton Mountains. These are particularly well shown on the vertical western face of the little ridge.

Near Lytton.

Between the mouth of Botanie Creek and the bank of the Fraser, immediately north of Lytton, the rocks are all gray granite, much de-

composed and somewhat foliated by pressure, with the development of secondary mica.

The Botanie Mountain mass, separating the stream of the same name from the Fraser, wherever examined, on its eastern and western slopes and along its crest, appears to consist almost entirely of dark greenish and blackish dioritic rocks, including quartz-diorites, but sometimes very rich in hornblende. These are generally rather fine-grained, but occasionaly coarse and medium-grained, and somewhat resemble the hornblendic granites of Lytton Mountains, though here decidedly more basic in composition. Gray granites of the ordinary type, were also seen near the south-eastern edge of the ridge, on the Fraser Valley, and at its northern end, but sparingly. Numerous narrow bands of bedded or foliated rocks also occur throughout, their general strike being parallel to that of the run of the ridge, but their dimensions are so small that it would be impracticable to represent them upon a map of the scale of the present, even if it should be proved possible to define them with accuracy. Botanie Mountain.

Similar dark diorites and mica-diorites, were found on the lower part of La-loo-wissin Creek, where it cuts across the line of the Botanie Mountain ridge, and these become coarser grained and assume a granitic aspect, on approaching the mouth of the creek on the Fraser. To the north of La-loo-wissin Creek, along the east side of the Fraser Valley, rocks of apparently identical character prevail, till eventually concealed by the Tertiary volcanic beds near the mouth of the Three-lake Valley. Along this part of the Fraser Valley, these rocks are all very much decomposed and shattered, an effect elsewhere explained as being due to their proximity to the main line of the Tertiary volcanic eruptions (pp. 201 B, 204 B). They weather down readily into bare rubbly slopes of débris, producing forms which resemble those of the "bad land" hills in parts of the Great Plains. La-loo-wissin Creek. Shattered rocks.

On the west side of Fountain Ridge, near the Fraser River, the Cretaceous rocks are cut by a couple of granitic masses of relatively small size, and perhaps to be regarded as representing merely large dykes of granite. These are medium-grained granites of speckled black and white aspect, and on microscopical examination by Mr. Ferrier, prove to be hornblende-granites and biotite-hornblende-granites.* Similar intrusions in the Cretaceous were found on the west side of the Fraser between Lillooet and the mouth of Bridge River, and some miles up Bridge River. Many more of the same kind might doubtless be discovered by detailed search, but these are sufficient to show Granites cutting Cretaceous rocks.

* Appendix I., Nos. 91, 92.

that some at least of the granites of the region date from a period later than that of the deposition of the Cretaceous rocks.

Eleven-mile Creek to Pavilion Creek.

The area of plutonic rocks represented as extending from Eleven-mile Creek to Pavilion Creek on the east side of the Fraser, has been examined chiefly in its northern part, the outlines given to its southern extremity being more doubtful. It consists almost entirely of dark-greenish, often markedly coarse diorite, which may in part become a hornblende-granite. This rock is not only jointed but is also much shattered, and presents none of the appearance of a granitoid eruptive as seen from a distance. It decomposes readily in some places, and is cut by numerous dykes referable to the Tertiary volcanic period. The most notable point about this occurrence is, however, the manner in which the diorite is here inextricably mixed with broken stratified diabase, a circumstance elsewhere described (p. 88 B).

Near Leon Creek.

Further up the Fraser Valley, between Kelley and Leon creeks, another small granitic mass occurs, of which the relations to the adjacent bedded rocks are similar to those of the last, and are also elsewhere noticed (p. 93 B). This is more distinctly a granite than the last, but contains a good deal of hornblende.

West end Marble Cañon.

The granitic area found at the west end of Marble Cañon, consists of homogeneous gray granite of the usual type, generally micaceous, but sometimes with a certain proportion of hornblende. It differs much in appearance from the adjacent dark dioritic eruptive, above described as occurring on the lower part of Pavilion Creek.

Chi-pooin Mountain.

The granite of the Mount Martley and Chi-pooin Mountain area resembles that of Marble Cañon. It is gray, medium grained and generally very homogeneous; usually a biotite-hornblende-granite, but passing into a biotite-granite. About the somewhat plateau-like summit of Chi-pooin Mountain, the granite* is cut by several series of jointage planes in such a manner as to cause it to break out in slab-shaped pieces. These are weathered in places into rounded forms and resemble piles of loose boulders, though practically undisturbed.

Granitic area between Nicola and Guichon Creek.

The largest area of granitoid rocks contained in the Kamloops map-sheet, is that which constitutes the wide region of broken plateau lying between the Nicola Valley and Guichon Creek. This area is almost entirely characterized by hornblende-biotite-granites passing into mica-diorites in many places. No specimens of true biotite-granite occur among those brought back, and wherever the character of the rock was noted in the field, it is described as being more or less hornblendic; but

* Appendix I., No. 85.

it is of course possible that such granite may be found in parts of this extensive tract which have so far merely been seen from a distance.

The western part of the area, for a width of from three to five miles along that margin, is principally composed of homogeneous greenish diorites and quartz-mica-diorites of granitoid aspect, but sometimes very rich in hornblende.* These occur about Wood's Creek, on the lower parts of Pu-kaist′ and In-ki-kuh′ creeks, to the west of Spaist Mountain and in the southern extremity of the area in the Promontory Hills. In Wood's Creek, pebbles of magnetite are found, which probably come from veins in the adjacent diorite, here somewhat epidotic and decomposed.

Dioritic character of western border.

Magnetite.

No distinct line is found between the rocks just spoken of and the gray hornblende-biotite-granites which constitute the greater part of the area, including apparently nearly all of its western portion. On the upper part of the In-ki-kuh′ Valley and about the head of Skuh′-un Creek, the rocks of this class hold both a pink and a white felspar. The granite of Spaist Mountain was observed to be unusually shattered, containing many veins of epidote and quartz, with pegmatite veins and dykes of fine-grained granite. Some contact phenomena, seen along the eastern edge of the granite mass on Guichon Creek, are elsewhere referred to (p. 144 B).

Western part.

Contact phenomena.

The general plateau-like form of this granitic region, is well seen from high points, such as Spaist Mountain, but at the same time its rough, hummocky and broken character in detail is very apparent. Considerable areas of bare whitish granite may be observed over all parts of the area. About the head of Skuh′-un Creek, and to the eastward for some miles, the surface of the plateau was found to be composed largely of broken angular or partially rounded granite blocks, probably due to the action of the frost and weather since the glacial period, as the granite is here very much jointed.

General appearance of plateau.

The northern part of this great tract, is largely concealed by Tertiary volcanic rocks, but where it can be followed, to the west of Mount Glossy and near the lower part of Barnes Creek, gray granitoid diorites, similar to those found elsewhere in the western portion of the area, prevail. Due west of Mount Glossy and near the edge of the Nicola rocks there, dark gabbro-like diorite was found in some places, and on the east side of Barnes Lake a rock determined as a granite-porphyry, occurs.† Further north, this eruptive mass occupies a considerable area on both sides of the Thompson, of which the northern extremity is cut by the

Near Barnes Creek

* Appendix I., Nos. 80, 81. † Appendix I., No. 83.

section described on page 118 B, where some notes on its general character and relations have been given. It will suffice here to add, that the western part of this mass, near its contact with the Nicola rocks, is often a porphyritic diabase or gabbro,* while its eastern part is usually a dark mica-diorite. On the south side of the river, in some places, it again tends to become a granite-porphyry and is often inextricably mixed with large masses of rocks of the Nicola formation, highly altered.

Near Eight-mile Creek.

Near Eight-mile Creek, what is probably an extension of the same plutonic mass, appears from beneath the Miocene volcanic rocks as a gray diorite, still holding a little mica. A third projection, bordered on both sides by rocks of the Nicola formation, is again formed chiefly of gray diorite, considerably decomposed in places, with some red granite on its north-eastern edge. The latter may be of newer or older date than the general mass, which is probably connected at no great depth with the main granitic area to the southward. (See p. 118 B.)

South of Penny station.

To the south of Penny station, another small patch, surrounded on all sides by volcanic rocks, appears to consist chiefly of rather fine-grained, pale-gray diorite, though specimens of a diabase similar in appearance, were also collected here by Mr. McEvoy. Also in connection with this great granitoid area, may be mentioned a small occurrence of blackish and greenish diorite, sometimes containing quartz, found on the east side of Guichon Valley. This runs southward, beyond the edge of the map, nearly to the Nicola River. It closely resembles the rock of the adjacent Promontory Hills, on the opposite side of the Guichon Valley.

Bonaparte Lake.

In the vicinity of Bonaparte Lake, a large area of granitic rocks appears where the volcanic Tertiary rocks have been removed by denudation. The entire coast of the lake, with most of its adjacent hills, and particularly the range named as the Rim Hills, to the north of the lake, may in fact be described as granitic. The rocks are so similar to many of those already noticed, that they scarcely require more than mention. They consist chiefly of gray or sometimes pinkish hornblende-biotite-granites, hornblende-granites and diorites of granitoid aspect; the last-named being probably the least common rock. To the westward, rocks of the same character continue in the eroded valley of the Bonaparte to about the confluence of the North Branch, where they are represented by a somewhat peculiar syenite, containing some augite and of a pinkish colour.†

North Branch of Bonaparte.

* Appendix I., No. 84. † Appendix I., No. 90.

A southern spur of the same granitic area, which reaches Granite Lake, consists of hornblendic granites similar to those of Bonaparte Lake. At Granite Lake, these are gray in colour, and are traversed by pegmatite veins and contain masses of greenstone and of green schistose rocks, with which they appear to form a contact in this vicinity. Granite Lake.

Near Uren's, further west on the Deadman River, the plutonic rocks seen are probably an extension of the same mass, though now isolated by the volcanic overflows of the Tertiary. They are much covered with drift, rendering their outline uncertain, but appear to be chiefly dark, highly hornblendic diorites. Another branch of the Bonaparte Lake area runs toward Skoatl Point. This likewise consists of gray granites, probably in the main hornblendic, though much covered by drift deposits and therefore seen only in occasional isolated exposures.

At Tsin-tsoon'-ko Lake, a small area of gray biotite-hornblende-granite occurs. Tsin-tsoon'-ko Lake.

The area of granitic rocks indicated on the map to the east of Bonaparte Lake and near the North Thompson River, has been very imperfectly defined. It occupies a rough, broken and wooded country, but so far as seen, appears to consist of rather hornblendic gray and greenish-gray granites, with some diorites. Granitic areas near North Thompson.

The definition of the next small area of granite to the southward, that to the west of the North Thompson and south of Skull Creek, is equally imperfect, its western limit not being properly ascertained. Where seen, it consists of gray hornblende-biotite-granite of rather fine grain.

Continuing to the southward, a considerable area of granitic rocks is found on the east side of the North Thompson near Sullivan Creek. The characters of these are rather peculiar, but they show a decided resemblance in texture to those of the Edwards Creek and Jamieson Creek intrusions of the same vicinity. The granite is generally pinkish-gray, and when the bisilicates are not entirely decomposed, hornblende is the preponderant one. The felspar crystals are rather large and somewhat porphyritic, and the stratified rocks near the granite, show, both here and in the other cases mentioned, very considerable alteration. Sullivan Creek.

The Jamieson Creek granite mass may extend further to the northward than shown on the map, as its limit was not defined in that direction. It is of fine or medium grain and either gray or pinkish in colour, the latter tint being apparently due to the oxidation of iron pyrites contained in it. It is everywhere considerably decomposed, the bisilicates being scarcely recognizable, and is traversed by many small Jamieson Creek.

and some large quartz veins. The latter continue into the adjacent hardened and slightly micaceous argillites, and are those which have been located as mining claims (p. 336 B). To the south of Jamieson Creek, the granite runs out in dykes among the schistose argillites. It is evidently the occurrence of the granite as an intrusion in the stratified rocks at this place, that has resulted in the production of the auriferous veins of the locality, and its extent and character thus assume a certain degree of economic importance.

Auriferous veins.

Near Edwards Creek.

Near Edwards Creek, another plutonic mass enters the area of the map from the east. This is a gray, to pinkish-gray, rather coarse-grained rock, much jointed, with numerous blade-like and twinned felspar crystals, considerably decomposed, and often containing much iron-pyrites in scattered grains. It has been microscopically examined by Mr. Ferrier, who describes it as a somewhat porphyritic syenite.* Its eastern edge, in some places, where in contact with the surrounding rocks, becomes a diorite Specimens of its pyritous and rusty portions subjected to assay, afforded traces of gold (p.312 B). It evidently represents a truly intrusive rock, and the stratified materials in its vicinity are again found to be much altered.

Syenite carrying gold.

Three miles south of Edwards Creek, and also on the east side of the North Thompson, a small mass of greenish-gray diorite appears in the bottom of the valley, but the detrital deposits prevent its precise definition.

The peculiar and somewhat diversified mass of crystalline rocks which forms Battle and Cherry bluffs on Kamloops Lake, is elsewhere described in connection with the Tertiary volcanic rocks of the vicinity (p. 158 B) of which it is believed, at least in great part, to have constituted the vent. To the south-east of the Cherry Bluff exposures, after an interval of about three miles covered by Tertiary volcanic materials, rocks of the same kind are again found in the ridge named Coal Hill on the map. These are gabbros and dark diorites, containing some mica.† Further to the eastward, near Peterson Creek and Separation Lake, in the same area, these are replaced by fine-grained gray granitoid rocks, and it is possible that plutonic rocks of two distinct periods are here represented.

Coal Hill and vicinity.

In some places, the rocks of this area, which is about ten miles long in all, have suffered considerable local alteration and decomposition, resembling that which is seen to have affected the rocks of Cherry Bluff. At or near the west edge of these rocks, at their northern extremity, thin veins of magnetite were found by Mr. McEvoy.

Magnetite.

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*Appendix I., No. 89.

†Annual Report, Geol. Surv. Can., Vol. V. (N.S.), p. 60 R.

On the edge of the mass overlooking Edith Lake, a very coarse diorite, containing magnetite in large crystals, was observed to occur.

Granite west of Moore Creek.

About seven miles to the southward of Kamloops, the northern end of one of the largest granitic areas covered by the map is found. This area runs southward by Trout Lake and parallel to the direction of Moore Creek, to the north shore of Nicola Lake, with a total length of nearly thirty miles. It is identified throughout with a rather high and somewhat broken plateau country, and except where overlapped by Tertiary volcanic rocks near its northern end, is everywhere found to be surrounded by rocks of the Nicola series. The eastern edge has been pretty accurately determined, but much of its western outline must be regarded as approximately correct only, as shown on the map, this part of the region being in general not only thickly drift-covered, but also heavily wooded and difficult to explore.

Lithologically uniform.

Wherever examined, the rocks of this large area appear to be very uniform and homogeneous in their character, consisting as a rule of gray biotite-hornblende-granite of medium grain, generally with a considerable, and sometimes with a rather large quantity of quartz. True biotite-granite also occurs, but no highly hornblendic granites or diorites have been observed, except in the instance of a very coarse diorite, locally developed, near the west end of Trout Lake, but which may not have the same date or origin as the main granite mass.

Contact phenomena.

The granite is sometimes more or less distinctly foliated, for a narrow width near its contact with the stratified rocks, but this effect is quite evidently due merely to the conditions of contact, which are elsewhere referred to at greater length (p. 129 B). In this area, the granite was in several places found to weather easily and to become superficially decomposed. This tendency, when in connection with well marked jointing, gives rise to miniature tors, and to the production of great numbers of boulders which still remain nearly in place. Granite surfaces breaking up into such boulders, were particularly noted on the plateau between Moore Creek and the head of Clapperton Creek.

Development of quartz veins.

In the neighbourhood of the edges of the granite, the stratified rocks are frequently penetrated by quartz-veins, and it is highly probable that the metalliferous veins of the vicinity of Stump Lake, are connected in their origin with the production or intrusion of this neighbouring granite mass.

Campbell Creek and Trapp Lake.

About Campbell Creek and Trapp Lake, another important granitic area is in part covered by the map. The granites composing this area are not dissimilar in appearance to those of the last, but are somewhat

more hornblendic, being either hornblende-granites or hornblende-biotite-granites—in some cases possibly quartz-diorites.* The rocks generally, differ little over the whole area, but on the west side of Trapp Lake, near their contact with the stratified materials, are represented by a black-and-white diorite. The character of the contact of these granites with the rocks of the Nicola formation is noted on another page, as well as the fact that they include, to the east of Newman's, some much altered remnants of the diabases of that series (p. 123 B).

Near Douglas Lake.

The granitic area to the north of Douglas Lake, is occupied by a nearly homogeneous mass of medium to somewhat coarse-grained gray granite, which is in some places characterized by a preponderance of hornblende, in others by that of mica. It was seen in several localities to be cut by conspicuous parallel jointage planes, in such a manner that it might easily be quarried in well chosen spots. The fine amphibolites and argillites which appear to surround this mass, are considerably altered and disturbed, and are traversed by numerous small quartz veins.

GLACIATION AND SURFACE DEPOSITS.

Importance of surface deposits.

The character and arrangement of the surface deposits which cover the older rocks in this district, as elsewhere in British Columbia, are to be explained chiefly by the events of the glacial period. It is thus important, even from a strictly practical point of view, that the nature of the changes brought about during this period should be understood. It is nevertheless the case that the history of this period, owing to the indeterminate character of much of the evidence relating to it, is as yet imperfectly known, and considerable diversity of opinion prevails as to the explanation of some portions of the evidence. While difficulties of this kind yet remain even in the little-diversified and closely studied eastern parts of North America, and in Europe, it is not surprising that they should also attend the history of the same period in British Columbia, where the varied and bold relief of the surface tends greatly to complicate the investigation. The researches carried out in this province have, however, already resulted in the discovery of some interesting facts, which are not only important locally but bear also upon the general questions of glaciation.

Economic features.

The most obvious effects of the period of glaciation on the district here referred to, are those connected with the transport and distribution of débris or, 'drift,' which has gone to form the boulder-clay,

* Appendix I., No. 87.

has been left in the shape of moraines, or appears as the material of the numerous terraces which are everywhere so characteristic a feature of the country. "The great accumulations of loose material formed at this time are also responsible, though less directly, for changes in the drainage system of the country, by the blocking up of pre-glacial river-valleys, leading to the diversion of streams or the formation of lakes. From an economic point of view, the geology of the glacial period has some features of special interest. It has determined the character of the soil, and must also be taken into account in the investigation of the superficial deposits in which gold placers are worked." *

Previous review of glacial history of British Columbia.

In a paper published some years since in the Transactions of the Royal Society of Canada,† on the Later Physiographical Geology of the Rocky Mountain region in Canada, with special reference to Changes in Elevation and the History of the Glacial Period, I have endeavoured to give a comprehensive review of the events of the glacial period in British Columbia as a whole, and to connect these with those of the adjacent area of the Great Plains. This review was based upon the very numerous observations made by me in various parts of the whole region described, most of which are recorded in the reports of the Geological Survey. The method of treatment adopted in it is, however, intimately connected with certain hypotheses as to the course of events, some of which must be considered as still open to question, while all are held subject to modification in the light of new facts. In this Report, it is proposed to record the principal observed facts within the district covered by the map to which it relates, with as little reference as possible to the theoretical explanations which these may appear to warrant. To a certain extent, however, the sequence of events during the period of glaciation is so well proven, as to admit of the grouping of the observations under headings approximately in their order of occurrence.

Historical scheme suggested.

To provide the reader with some scheme of events, with which the facts subsequently grouped by kind may be compared, a provisional outline of the glacial history of the Cordillera will in the first place be presented. Though at the time it was written this appeared to accord with all the observations collected during many years of work in the region, it may probably be already subject to modification in some particulars. Care will be taken to note the facts which appear to conflict with its tenor, although I am not yet in possession of a sufficient body of such facts to induce me to undertake a general revision of the scheme.

Subject to revision.

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* Report of Progress, Geol. Surv. Can., 1877-78, p. 133 B.
† Vol. VIII., 1890.

What follows on this subject, is quoted, with little alteration, from an article published in the American Geologist,* which was prepared by me as a summary of the longer paper first referred to.

Early maximum of glaciation.

It would appear, that that part of the Cordilleran region of the West included in Canada, was, during an early and most severe phase of the glacial period, buried beneath a great confluent mass of glacier ice. Evidence of the existence of a system of glacial scoring and striation due to the southern part of such a great glacier, was obtained at an early stage of the investigation of the southern portion of the Interior Plateau of the province. Several hypotheses at first presented themselves as likely to explain the existence of this general (as distinct from the obviously local) glaciation of the region, but these were gradually eliminated or modified at later dates, and the conclusion above stated was arrived at. In 1887, in the course of an exploration of the Yukon district, evidence was found of the north-westward extension of the same great ice-mass, and its limits were approximately ascertained in that direction also.

Cordilleran glacier defined.

Having thus discovered the area of this great glacier, it was proposed to name it the *Cordilleran Glacier*, in order to distinguish it from the second and still larger ice-cap, by which the north-eastern part of the continent was at about the same time more or less completely covered.†

The Cordilleran glacier, as thus defined, had, when at its maximum development, a length of nearly 1200 miles. The main gathering-ground or *névé* of this ice-sheet, was contained approximately between the 55th and 59th parallels of north latitude, that part of the ice which flowed north-westward having a length beyond these limits of 350 miles, that which flowed in the opposite direction a length of about 600 miles. When at its greatest, a portion of its ice also passed off laterally by gaps transverse to the Coast Ranges, and filled the wide valley between Vancouver Island and the mainland. The ice there divided and flowed in opposite directions, as the subsidiary, but yet large, glaciers of Queen Charlotte Sound and the Strait of Georgia. Ice from the main *mer de glace* does not appear to have crossed the Rocky Mountain range proper, on the other side, although considerable local glaciers were at the same time developed on the north-eastward slopes of this range.

Development on the Coast.

Thickness of the ice.

That portion of the Cordilleran glacier which moved south-eastward along the Interior Plateau of British Columbia, is now known, from

* September, 1890, p. 153. † Geol. Mag., August, 1888.

numerous observed instances of striation crossing high points, to have covered the summits of isolated mountains of 7000 feet and more in height; a circumstance which implies that the ice reached a general thickness of 2000 to 3000 feet above even the higher tracts of the plateau, while it must have attained a thickness of over 6000 feet above the main river-valleys and other principal depressions of the surface.

During the maximum of the Cordilleran glacier, it appears that the Cordillerian region stood at a level considerably higher than it now does, while an important part at least of the Great Plains was probably depressed to such an extent as to admit waters in connection with, and at the level of, those of the sea. The eventual retreat of the Cordilleran glacier was contemporaneous with, if not caused by, a subsidence of the mountain region. Cordillera elevated. Subsidence.

The first effect of the decay of the great glacier, may be supposed to have been the production of lakes upon its surface or within the central part of the southern portion of its area, in the relatively dry region of the Interior Plateau. Along the borders of one or more such englacial lakes, terraces, composed of material resembling boulder-clay, were formed on projecting highlands.* The best marked and highest terrace to which this origin is attributed, has an elevation of about 5290 feet above the present sea-level, and this terrace (or others at or about this level) has now been recognized in a number of places.† Such 'englacial' lakes may have continued to increase in size, and to become lower in level, for some time, while a general subsidence also progressed. There is further, some evidence to show that, after the final draining of these lakes and as the great glacier retreated from the Interior Plateau, it was followed by gradually deepening water which was in communication with that of the sea. The boulder-clay deposit of the Interior Plateau is believed to have been formed principally during this retreat, at, or in water contiguous to, the retiring ice-front. The lower boulder-clay of the littoral was laid down under similar circumstances, but at a somewhat earlier stage in the glacial decadence, and as the submergence became deeper, stratified interglacial silts were formed above it in the same region. Decay of great ice-sheet. Following submergence.

The next change is supposed to have been a reëlevation of the Cordillera, during which most of the higher terraces of British Columbia were formed. Some further evidence of this rise is afforded by the removal at about this time of much of the previously formed boulder- Reëlevation and second maximum of glaciation.

* These must at the time have resembled the *nunataks* of Greenland.

† See, however, in this connection, p. 249 B and foot note to p. 282 B.

clay from some of the larger river-valleys.* The land probably stood as high as (and possibly higher than) it now does relatively to the Pacific, and in consequence of its elevation and the severe general conditions of the climate of the period, it became again covered to a considerable extent by glaciers, which, however, were as a rule, of a local character and in evident relation to the various mountain ranges.

Second subsidence and period of stability.

Following the maximum of this second period of glaciation, came apparently a second subsidence, less in amount than the first, but sufficient to depress the Cordilleran region generally, to a level about 2500 feet below that which it holds at the present day. At this stage, and while glaciers of considerable size still occupied the mountain-valleys, and the position of the *névé* of the former Cordilleran glacier was probably held by an ice-cap of some size, the land remained nearly stationary for a long interval, and remarkable and important silt deposits, well bedded and of considerable thickness, were tranquilly laid down in different low tracts scattered along the Cordilleran region for a length of some 1200 miles. These deposits, the writer has in previous publications referred to as the *White Silts*, and as observations accumulated, it at length became evident that these silts possess more than a local significance. They appear, in fact, to constitute a well marked formation, characterizing a definite and long maintained stage of stability in the glacial history. In the various more or less completely separated basins in which they occur, their level is so nearly identical, as apparently to show that this must be referred to a common cause, which it is believed, in consideration of all the circumstances, and particularly in view of the vast area which the observations here referred to cover, can have been no other than the level of the sea at the time. No morainic or other accumulations have been found, such as to account for the production of lakes, in which these silts might be supposed to have been deposited, and had they been formed in separate lakes, held in either in the manner suggested or by glacier-dams, they would, in a region of such bold relief as the Cordillera, be expected to occur at very different levels in each basin.

White Silt formation.

Final retreat of glaciers.

The evidently somewhat rapid retreat of the already reduced glaciers of the second period, was apparently not in relation to subsidence of the Cordillera, but, on the contrary, seems to have been contemporaneous with, or was soon followed by, a progressive movement in elevation. It is supposed that this final decay of glaciers occurred chiefly in connection with a general amelioration of climate, by which the close of the

* The date assigned to this removal, depends on the existence and relations of the silt deposits next alluded to, in the same valleys.

glacial period as a whole was brought about, as to the cause of which no opinion is here offered.*

Latest movements of land.

It is worthy of note, that most of the long fiord-like lakes of the mountain regions of British Columbia, can be shown to occupy portions of the abandoned beds of the glaciers of the stage of the White Silt formation. To the elevation which began about the time at which we have now arrived, the draining of the White Silt water, together with the formation of all the lower-level terraces, is supposed to be due. There appears, however, to have been one well marked pause, during which the littoral, at least, was at a height about 200 feet lower than it now is, and there is in addition some evidence of a succeeding movement in elevation of several hundred feet, which, if it occurred, constitutes the last important change of the kind in the region.†

STRIATION AND SCORING OF ROCK-SURFACES.

Direction of observed striation.

The direction of motion and thickness of the ice-mass of the Cordilleran glacier, have been determined chiefly on the evidence of glaciated rock-surfaces met with at considerable elevations, such as the projecting points of mountains or the higher parts of the Interior Plateau itself. The more important observations of this kind have been detailed in the paper already referred to, but some additional observations of the same nature have since been made, while others, which did not appear to require mention there but are important locally, were not included in it. It may be well, therefore, in the first place to give a summary list of the principal observed localities of glaciated rock-surfaces in the district included by the map, with the direction indicated by each and its height above the sea. In the following list the localities already published are those included in parenthesis. In the paper from which these are here quoted, the latitude and longitude of each observation-point was recorded, but, because of the map now printed, upon which the observations are plainly indicated, it is no longer necessary, in the cases here mentioned, to resort to this indirect method

* Two principal periods of glaciation are here postulated, because evidence of more than two has not been obtained in any particular region in the Cordillera. It is, however, by no means certain that the two boulder-clays of the Strait of Georgia and the two boulder-clays of the Cariboo region (Annual Report, Geol. Survey, vol. VII., p. 24 A) correspond, the latter being high up, and far in towards the central *névé* region. The possibility of *several* great oscillations in temperature is by no means excluded by the facts so far ascertained.

† *Cf.* Canadian Naturalist, February, 1878.

of placing them. The directions of striation stated are in all instances true bearings :—

Above 3000 feet.

(1). GLACIATION NOTED AT LEVELS ABOVE 3000 FEET.

Locality.	Height above sea, in feet.	Direction.
Plateau between North Thompson River and Deadman River.		
South of Bonaparte Lake	4640	S. 35° E.
(Skoatl Point)	5840	S. 37° E.
2 miles E. of Young Lake	4170	S. 19° E.
(6 miles N.E. of Deadman Lake)	4220	S. 30° E.
(3 miles westward from Tsin-tsoon'-ko Lake)	5220	S. 34° E.
Poison Hill	5370	S. 41° E.
1 mile E. of Caribou Lake	5810	S. 48° E.
(Basalt Point)	5840	S. 35° E.
Near Porcupine Ridge	5920	S. 39° E.
3½ miles south of Tranquille Lake	4830	S. 40° E.
Plateau between Thompson and Nicola Valleys, and Valley which connects Nicola Lake and Kamloops.		
6½ miles east of Ashcroft	3150	S. 55° E.
North part of Mount Glossy	5950	S. 40° E.
(Cinder Hill)	5070	S. 50° E.
Between Pu-kaist and In-ki-kuh' Creeks	4000	S. 13° E.
(Spaist Mountain)	5780	S. 28° E.
Plateau S.W. of Spaist Mountain	5520	S. 27° E.
" " "	5550	S. 30° E.
" " "	5350	S. 28° E.
" " "	5200	S. 27° E.
Choo-whels Mountain	6000	S. 35° E.
(Plateau 14 miles S. of Kamloops)	4190	S. 31° E.
Edge of high plateau 2 miles S.S.W. of Separation Lake	abt. 3500	S 6° W to S 27° W.
3 miles N.W. of Head of Stump Lake	3550	S. 20° W.
Little Timbered Hills	4800	S. 15° E.
Between Clapperton and Guichon Creeks	4200	S. 35° E.
Douglas Plateau.		
2 miles E. of Stump Lake	3500	S. 15° W.
½ mile N.E. of Glimpse Lake	abt. 3800	S. 9° W.
2½ miles east of last	4030	S. 18° E.
Other Localities.		
Meander Hills	3240	S. 12° W.
(Nicoamen Plateau)	5630	S. 13° E.
Lytton Mountains	abt. 6200	S. 23° W.
(Mount Murray)	6880	S. 10° E.
Pass N.W. of Mount Murray	5480	abt. S. 20° E.
Trachyte Hills	5200	S. 51° E.
(Arrowstone Hills)	5500	S. 35° E.
(Summit E. of Paul's Peak)	3520	S. 51° E.

(2). GLACIATION NOTED AT LEVELS BELOW 3000 FEET.

Below 3000 feet.

Locality.	Direction.
North Thompson River above Indian Reservation	S. 2° E.
Inner Valley, near Edwards Creek	S. 13° E.
East side Stump Lake, north end	....
Above and behind Battle Bluff, N. of Kamloops Lake	N. 85° W
Hills south of Semlin Valley	S. 30° E.
2000 feet above Fraser River, W. side, 4 miles S. of Lytton	abt. S.

Number of observations above and below 3000 feet.

In explanation of the observations included in the above list, it may be stated, in the first place, that the small number of these referring to levels below 3000 feet as compared to those at greater elevations, affords no true index of the relative frequency with which glaciated rock-surfaces occur above and below this plane. If all the glaciated surfaces met with below 3000 feet had been duly entered, probably a hundred observations might have been recorded, but, as a rule, glaciation met with at such lower levels was not specially noted, being obviously so much affected by the bold relief of the country, and by the tendency of the ice to follow the main troughs in the directions of their lengths. At high elevations, on the contrary, glaciation was always sought for, and carefully noted when found, though the disintegration of the rock-surfaces is frequently such that no distinct striation, but only the general forms of the projecting parts, still remain. In the examples collected in the list, however, no merely general evidence of this kind is included. In nearly all the recorded instances of glaciation at high levels, the directions have also been obtained either from approximately flat surfaces, or from slopes at right angles to the general direction, as it is notable that on oblique slopes the direction always varies, to an indeterminate amount. Some of the recorded directions, however, even those obtained on points of very considerable height, were still obviously influenced by the vicinity of more elevated tracts or by that of important depressions. In such cases, a study of the local conditions nearly always shows that the ice was affected by a tendency to veer away from the elevations and to slant down towards the hollows. To determine all the local deflexions thus produced in a great mass of ice which moved across a broken country like this, would be an almost endless task, even if the instances of well-preserved glaciation were much more numerous than they are. In a general way, it may be stated that the ice appears to have moved in more or less complete parallelism with the larger valleys below the 3000-foot contour, follow-

Influence of local features on direction.

Particularly at lower levels.

Differential motion.

ing their trend in the sense which agrees in each case most closely with that of the main direction of its motion. In this respect, these larger valleys appear to have acted, in imposing their direction on the mass, much as the rifling does on the bullet in a gun-barrel, but it is impossible to say to how great an extent what is known as 'stripping' in the illustration cited, has occurred. In other words, it is probable that even (and perhaps particularly) at the time at which the thickness of the Cordilleran Clacier was greatest, the lower parts of the mass followed the larger valleys, while the higher parts broke away from these and continued to pursue the general direction. It must further be remembered, that when the ice-sheet finally disappeared, its thinned and melting edge must have occupied each part of the district successively, and that at this time tongues or lobes of ice projected southward in some of the larger valleys, when the ice-covering on intervening areas of higher plateau had vanished or had at least broken up into detached masses, which had ceased to participate in the general movement. The existence of small terminal and lateral moraines, in evident connection with such tongues or lobes, is the chief apparent evidence of this, but it is mentioned here as tending still further to account for the movement of ice along the valleys, and for the purpose of introducing the remark that the striation then and in this way formed, is not clearly separable in all cases from that produced by such differential motion in the main mass as may be supposed to have occurred.

Striation due to retreating edge of ice.

Average direction.

The mean direction of the general glaciation of the district included by the accompanying map, obtained from all the recorded observations at heights above 5000 feet (rejecting only the observation on Lytton Mountains which was taken on a sloping surface and was manifestly affected by the neighbouring great valley of the Fraser) is S. 33° E. If, however, several observations, with respect to which local circumstances were observed which explains their departure from the average, are discarded, a mean direction of S. 33.5° E is obtained, which is probably better, and may be accepted as an approximation as close as can be arrived at.

Correspondence with main trend of Interior Plateau.

In the paper which has already been several times referred to, the main direction of motion of the southern part of the Cordilleran glacier, is stated to have lain between S. 30° E. and S. 35° E., with which it will be seen the result of the present discussion, confined to the area of the Kamloops sheet, corresponds. A line drawn from the southern part of Stuart Lake, to Osoyoos Lake, along the centre of the Interior Plateau, and as nearly as possible parallel to its main direction, with a length of 450 miles, runs S.35° E., and with this the value here locally

G. M. DAWSON.—Photo. Aug. 26, 1890.

GLACIATED BASALTIC ROCK OF THE HIGH PLATEAU.

Near Porcupine Ridge. Elevation 5,930 feet.

arrived at may again be considered as practically identical. It is thus evident, that the relatively depressed, though often rough and irregular region, which has been named the Interior Plateau, bounded to the south-westward by the Coast Ranges and on the opposite side by the Rocky Mountains and Gold Ranges, has given direction to the movement of the whole southern part of the Cordilleran glacier.

Independence of local elevations.

Particular attention may be directed to the examples of glaciation met with on the higher parts of the Arrowstone Hills and the Sil-whoi'-a-kun region, between the North Thompson and Deadman rivers, because of the fact that no considerable area of equal height occurs to the north-westward (the direction from which the glaciating agent moved), for a distance of 350 miles. The character of the glaciated surfaces found on these rather notably high tracts of the Interior Plateau, is such as to show that heavy glacier-ice passed completely and uninterruptedly over them in the general direction already indicated, thus proving its practical independence of even the broader features of the local topography. This is very strikingly evident when standing upon the north-western edge of the Porcupine Ridge, whence a nearly level horizon is seen to extend to the limit of vision in the direction from which the ice came, while to the eastward of this direction, irregular elevations bordering the north-eastern edge of the plateau begin gradually to rise. (See Plate VI.)

Effect of the greater valleys.

It is unnecessary to attempt to follow in detail, the various local conditions which have resulted in producing directions of glaciation divergent from the normal one. The circumstances are, however, in some cases sufficiently obvious, when the arrows by which the observed directions are indicated on the map are examined in connection with the contour-lines. On such an examination it will be found that, in descending from the higher levels, an ever increasing degree of irregularity and complication is met with. It may be noted, however, in particular, that the great parallel valleys of the Fraser and lower part of the Thompson with the intervening and also parallel valley of Hat Creek, have together had so considerable an effect on the overlying part of the glacier as to impress upon it a nearly due southward direction of motion, even where it crosses a point so elevated as that of Mount Murray. The important valley of the North Thompson, by means of the massive rib of ice which must have filled it, has also exerted an important directional effect.

Divergence usually eastward.

It appears also to be brought out, by an examination of the region covered by the map, that when the occurrence of opposing highlands forced the ice to diverge from its general direction, the divergence,

other things being equal, usually occurred to the eastward rather than to the westward. From this it seems reasonable to conclude that, in this part of the Interior Plateau, the weight of ice superposed on the western side was greater than that on the eastern, the maximum accumulation occurring here in the vicinity of the Coast Ranges.

Abnormal directions near Kamloops Lake.

In that part of the Thompson Valley which extends nearly due eastward from the mouth of the Bonaparte, for about fifty-eight miles, and which includes Kamloops Lake, some rather remarkable instances of glaciation nearly parallel in direction to the valley have been noted. Glaciation of this kind is found on the vertical front of Battle Bluff, near the level of the water of the lake, and again in the upper valley immediately behind and above the bluff at a height of 1000 feet above this level. Similar glaciation was again noted, in several places, on the hills to the north of the valley, some miles east of the Kamloops sheet.

Probable differential movement.

It is by no means certain in what manner this aberrant glaciation was produced, but as the general direction of glaciation is south-easterly and those parts of the valley affected run some degrees to the south of east, it appears to be probable that a lower part of the glacier-ice was here actually forced to follow this valley in an easterly direction. This is supported by the fact of the general tendency of the ice to deflect eastward where interrupted, and by the circumstance that the continuous range of high-lands to the south of the valley, did not permit any very great mass of ice to discharge southward by the Guichon Creek hollow; also by the observation of the abnormally great easting of the striation found on the summit of the ridge near Paul's Peak, which appears to be explicable only on the hypothesis of the addition, to the main flow, of an underlying mass with eastward motion, derived from the valley of Kamloops Lake. Without some such unusual condition, the motion of the ice would, in fact, here be likely to show a more direct southerly course that usual, for the great valley running southward from Kamloops by Stump Lake, must have been one of the main discharges for this part of the plateau. The ice, in fact, followed this valley, in an almost due southerly direction, till the valley began to turn to the westward, when it gradually resumed its normal course, across the Douglas Plateau.

How caused.

Direction across the Trachyte Hills.

An analogous case is met with in the abnormal amount of easting found in the striæ on the summit of the Trachyte Hills, where it would appear that a thick rib of ice moving along the Marble Cañon valley, exercised a directional influence on the main mass after its discharge from that valley.

It is, at any rate, scarcely probable that the glaciation of the second period was sufficiently extensive to result in the protrusion of glacier-tongues either from the Coast or Gold ranges so far into the area of the Interior Plateau as the vicinity of Kamloops Lake.* Neither are there any physical features in this vicinity such as to suggest the possibility of a local accumulation of glacier-ice during the second period of glaciation, although it may be pointed out that one or other of these occurrences might afford us an explanation of the manner in which the deep valley occupied by Kamloops Lake has been kept relatively free from drift deposits, a problem otherwise somewhat difficult of solution.

Extent of glaciers of second period.

SURFACE DEPOSITS OR "DRIFT."

In previous reports, the surface deposits referable to the glacial period have been divided for purpose of description under the heads of *unmodified drift* and *modified drift*. Drift deposits of one class or the other practically constitute the entire mantle by which the subjacent rocky surface is covered, for I am unable, within the limits of the Kamloops sheet, to adduce a single indubitable instance of the existence of gravelly or other unconsolidated materials referable to a time antecedent to the glacial period, while the most recent superficial deposits, such as those of the deltas of streams, fans, and alluviums of river-valleys, or those marking the positions of small lakes and ponds, with rock-slides or "screes," are inconsiderable as compared with the drift deposits proper. By far the greater part of the area is covered by drift, as above defined, probably not more than one-fifth or one-sixth of the surface in all being free from such cover.

Unmodified and modified drift.

In classifying the materials of the drift under the above heads, some consideration of the manner of their origin is involved, and it may be that the mode in which the deposits of the two classes were formed was not so different in character as is generally supposed. Practically, the unmodified drift includes the boulder-clay, the modified drift deposits of various kinds which have obviously in large part been formed by the re-arrangement of the materials of the boulder-clay and are generally speaking more or less distinctly stratified. The boulder-clay constitutes the lower member of the drift deposits, and the modified drift, where both are found together, invariably overlies it. Within the area of the map-sheet, no evidence has been obtained of the existence

But one boulder-clay recognized here.

*It may be explained here, that marks indicating the extent of the second glaciation in the Thompson and Nicola valleys appear on the map accompanying my paper on the Glaciation of British Columbia published in the Quarterly Journal of the Geological Society for 1878, but that the further and much more detailed examination of the country, now leads me to distrust the indications previously relied on in placing these marks.

of more than a single boulder-clay, though both in the littoral of British Columbia and in the Great Plains* two boulder-clays have been recognized, separated in each case by a well marked zone of stratified materials.

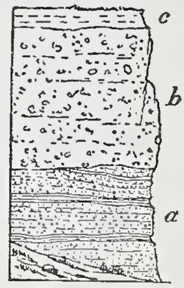

FIG. 9. SECTION ON BARNES CREEK.

a. Stratified gravels, silts and sands.
b. Boulder-clay, obscurely stratified.
c. Silty deposit; local inwash of the valley.

Beds below boulder-clay.

The only probable instance observed of gravels older than the boulder-clay, is in an interesting section on Barnes Creek, about four miles east of Ashcroft, at an approximate elevation of 2800 feet. Twenty-five feet of boulder-clay, containing some distinctly glaciated stones up to two or three feet in diameter, here overlies about twenty feet of well stratified gravels, silts and sands. The surface of the underlying beds appears to have been planed off to some extent. They are well compacted, and the gravels hold some stones six inches in diameter. The pebbles are often sub-angular, but none of them are striated. The conditions represented here may possibly be those just preceding the advance of the main ice-sheet.†

The Boulder-clay.

General character of boulder-clay.

The boulder-clay found in this district, differs in no essential respect from that found elsewhere in the northern part of the continent, and though varying somewhat in character in different places, preserves its well known features throughout. It consists of a paste of hard sandy clay, usually containing a considerable amount of fine sandy or silty material, and throughout it stones and boulders are generally abundantly though irregularly distributed. In colour, it varies from light brown, buff or yellowish to bluish-gray, the last-named being usually that characteristic of fresh exposures cut down to some depth from the surface, or of those which have been otherwise protected from weathering and sub-aërial agencies. Some of the contained stones are

* Also now in the Cariboo district, as before noted.

†Notable instances of gravel deposits, Pliocene and perhaps newer, have since (1894) been found in the Cariboo country to the north. Similar occurrences should now be sought for elsewhere. Their natural exposures are, as a rule, and necessarily, obscure and small.

found to bear traces of glacier striation and polishing, and a few are occasionally facetted. It is notable, however, that such scored and scratched stones are often rather scarce, and that a large part of the stones are well rounded and appear to have been shaped by ordinary water action like other pebbles. Local differences in colour and composition of the boulder-clay, are here not so well marked, nor can they be so closely correlated with the varying nature of the underlying strata, as for instance in some parts of the Great Plains, where the strata, being softer, are more easily incorporated as a part of the boulder-clay. Neither is the boulder-clay of this district so plastic and truly clayey in character as that of the St. Lawrence Valley or many parts of the Great Plains, where the disintegration of limestones, or of soft clayey beds of Cretaceous age, have respectively supplied much of the material. The contained stones are often, perhaps usually, chiefly those of each particular vicinity; but with these there is always a considerable and often a large proportion of stones of varied origin. In most places, a considerable part of these travelled stones is found to be obviously derived from some rock-exposures to the north-north-westward, in the line of the general direction of glaciation. This is particularly apparent when large surfaces of granitic rocks occur to the north-west of any particular place, as rocks of this class seem here, as usual, to have been specially productive of boulders. A part of this effect, doubtless depends on the generally superior elevation of the granitic regions. There is, however, considerable evidence of cross-mingling of material The results of this are least obvious in the higher parts of the plateau and most notable at somewhat lower elevations.

Local differences

Derivation of contained stones.

In the case of stones which can be clearly referred to their places of origin (as for instance granitic fragments on basaltic plateaux) an examination of all the notes made, shows that these have seldom or never been transported in large numbers for a distance greater than about ten miles, in the direction of the glaciation. In smaller numbers, however, they have in several cases been traced to a minimum distance of twenty or twenty-five miles in that direction.

Distance of transport.

The above remarks respecting the derivation of the stones and boulders of the drift, apply specially to those included in the boulder-clay itself or obviously derived from it. The stones found on the highest points to which drift has been traced, at heights greater than that which the boulder-clay is known to characterize, often show considerable diversity in character, and their origin cannot always certainly be traced. Again, in the lower and larger valleys, the material

of the drift, in consequence of the carrying power of the rivers, and possibly of other causes, is much more varied.

Main development of boulder-clay between 5000 and 3000 feet.

Speaking of the whole district included by the Kamloops sheet, as a result of the pretty complete examination of all its parts, it is very noticeable that, while many considerable areas even of the plateau country rise above 5000 feet, the greatest development of the drift deposits is found below this level. It is further probable that, though considerable quantities of drift occur in the deep and wide valleys which traverse the region, it is by no means so uniformly spread in these, and its mass, area for area, is smaller than that met with on some parts of the plateau above. To this general statement there are numerous exceptions, and though (as subsequently noted) there is reason to believe that the upper line of the heavy drift deposits is a rather definite one, it is impossible to fix any lower line for them. All that can be affirmed with certainty, is that the greatest average thickness and most continuous and unbroken development of drift deposits, is met with on those parts of the plateau between 5000 and say 3000 feet, above the level of the sea. The aggregate area of the parts of the plateau between these limits, constitutes probably half the entire area of the plateau region embraced by the map.

Further localization of areas of heavy drift.

It is further found, however, that the drift deposits are as a rule much thicker and more important over some considerable areas of the region than over others, while certain parts of the plateau and some of the mountainous tracts are notably free from such deposits, even at elevations where these are generally best developed. An attempt has been made to define these areas upon a map, by laying down all the observations bearing upon them in a graphic form. The result is too indefinite for precise delineation, but sufficient to enable the statement to be made that the following areas are as a rule notably drift-covered.—

1. Area composing the Green Timber, Bonaparte and Kuk-waus' plateaux, with the northern part of the Arrowstone Hills. 2. Area including the upper valley of Hat Creek and adjacent hills. 3. Area including the whole drainage system of Guichon Creek and comprising the upper parts of Pu-kaist' and In-ki-kuh' creeks on the west, with the heads of Cherry Bluff Creek and Peterson Creek on the east. 4. Southern part of the Sil-whoi'-a-kun Plateau, and part of the Tranquille Plateau east of Watching Creek. 5. Dome Hills and plateau about the upper part of Reservation Creek. 6. The Douglas Plateau.

Areas with scanty drift.

Of districts which are, on the contrary, notably free from drift deposits, the following may be mentioned :—1. The Marble Mountains. 2. The greater portion of the Pavilion Mountains, particularly

their south-eastern part. 3. The Lytton Mountains. 4. The Coast Ranges to the west of the Fraser, so far as included in the map.

The remainder of the surface of the country may be regarded generally as intermediate in respect to the development of the drift deposits.

Possible cause of differences noted.

On the hypothesis already outlined, it may be supposed that when the supplies of ice of the Cordilleran glacier began to fail and it entered its period of decadence, it must in the first instance have lost its head and motion, and while thus in an inert state, by processes of decay, it was in some places removed or melted away sooner than in others, forming pools, and eventually large englacial lakes, toward which the remaining ice would naturally begin to trend and in which greater deposits of drift material might accumulate. Some of these remaining ice-masses appear to have clung to, and continued to descend from certain of the mountain ranges and higher plateaux, while in other cases the very massive accumulations of ice filling the larger valleys may have persisted, though in an inert condition, long after the thinner ice overlying the adjacent plateaux had disappeared.

Erratics of the highest points.

Before proceeding further with the description of the drift deposits of the tracts below 5000 feet, it may be well to note what has been observed respecting the drift of the very highest points to which it has been traced. Without entering into this branch of the subject in great detail, it may be stated that small erratics of varied composition and origin, have been found over all the most elevated points to the east of the line of the Fraser River. The Clear Mountains, near the western side of the map, in a number of places comprised within about twelve miles measured on the length of the range, exceed 7000 feet in elevation, and the highest point, Cairn Mountain, has a height of 7650 feet. Small erratics, composed of rocks not seen in the vicinity, are found everywhere to the summits, though mixed with much angular material of local origin. On Tod Mountain, 7250 feet in height, situated twenty-four miles north-eastward of Kamloops and a short distance outside the eastern edge of the map, although no stones were met with on the actual summit which could be positively affirmed to be far-travelled, such were found at a short distance below the apex. On Za-kwaski Mountain, a few miles beyond the southern edge of the map, between the Nicoamen and Fraser, with an elevation of 6600 feet, a few granitic pebbles three or four inches in diameter, were found on the actual summit, which is composed of volcanic rocks. Again, on Porcupine Ridge, the culminating point of the high plateau to the north of the sources of the Tranquille, though the entire plateau is here composed of volcanic rocks, granitic boulders and pebbles were found in moderate abundance to the highest points at 6030 feet.

Having cited these more remarkable instances, it will be unnecessary to explain in detail that similar travelled stones are strewn over all the less elevated culminating points of the plateau, and that in many cases well above 5000 feet, these are met with in great abundance and in boulders of two, three or more feet in diameter.

Earthy drift at high levels.

On most of the points exceeding 6000 feet in elevation, the shattered rock of the locality itself is abundant in angular fragments, but besides this, and in addition to the sprinkling of erratics, there is generally a certain small quantity of earthy matter. This is usually sandy in texture, and though probably to some extent of local origin, is doubtless in part to be classed as drift material, although it presents none of the characters of a boulder-clay. The summits of the Clear Mountains were observed to be characterized by an unusually large quantity of such earthy material, but wherever hollows or light slopes upon which it could lodge and remain occur, it is never entirely wanting.

Absence of erratics in Coast Ranges.

In the eastern part of the Coast Ranges which comes within the limit of the Kamloops sheet, no instances of erratics at notable elevations were discovered, and generally speaking the quantity of incoherent material, apart from mere broken rock of local origin, is inconsiderable in all the higher parts of these mountains. This, I believe, to be probably due to the circumstance that the direction of flow of the ice, to which the transport of erratics generally must be attributed, was at all times from, rather than toward these ranges, and that they were probably among the last parts of the surface to be freed from an icy covering.

Terrace-like forms of boulder-clay deposits.

What has been stated above, on the greatest development of the drift deposits as a whole between heights of about 5000 and 3000 feet, applies in a special sense to the main mass of the boulder-clay. It is the remarkable quantity of this material which is spread over those parts of the country between the elevations mentioned, that chiefly justifies the general statement. At these intermediate heights, or in other words over the whole of the less elevated parts of the plateau proper, the boulder-clay is found in its greatest development. Here it often forms the actual surface in which the trees are rooted and not infrequently spreads for miles with a nearly level surface, between heights of 4000 and 5000 feet. All parts of the plateau to the south of Kamloops Lake and east of the Thompson, afford good examples of this though the rocky sub-surface is here an irregular one. The Green Timber plateau may also be cited, though the nearly level floor produced by its basaltic sheets, may here be supposed in part to account for the uniformity of the boulder-clay which covers it. In such regions,

several miles may often be travelled without finding a single projecting point of solid rock.

Thickness of boulder-clay.

Respecting the thickness of the boulder-clay, even where its spread is greatest, it is impossible to make any general statement. It evidently fills certain hollows to a considerable depth and often runs out upon rocky prominences within a short distance with a feather-edge. It is probably in some places at least a hundred feet thick, but no single section was observed within the area of the Kamloops sheet which showed such thickness. This paucity of good sections is readily explicable, for it is probable that its persistence over the lower parts of the plateau is to be accounted for chiefly by the circumstance that it has there not been subjected in any great degree to denudation.

Boulder-clay of higher plateaux.

In the course of the examination of the region, I found myself becoming accustomed to note the occurrence of 'ordinary plateau boulder-clay.' A difference was in fact observed between the boulder-clay of the plateaux and that seen in some sections in the lower valleys, which though one of degree rather than of kind is pretty obvious in its character. This consists principally in the somewhat more sandy and silty nature of the boulder-clays of the plateaux, which becomes most marked towards the upper limit of the deposit. But these plateau boulder-clays are also generally paler coloured than those of the lower levels and usually present drab, fawn or yellowish tints. This is doubtless in part due to their greater porosity, which favours weathering and oxidation by surface waters, but also, probably, to the very slow removal of the weathered superficial portions on these areas. The only fundamental difference is, however, that in the original texture of the materials.

Exposures of boulder-clay. Pavilion Mountain.

One of the best and most extensive exposures of boulder-clay, is found to the north of Pavilion Creek, about two miles eastward from the place at which the road begins its ascent to the Pavilion Mountain farms, and almost directly behind Captain Martley's house. A landslip which has occurred here on the upper edge of the valley, has produced a large bowl-shaped hollow, the bottom of which is strewn with great broken masses, while the sides present a cliff of about forty feet in height and several hundred feet in total length, composed almost entirely of boulder-clay. The material is here of a nearly uniform, pale yellowish-drab colour when dry, and so hard as to stand without much sign of waste in vertical faces of the whole height of the cliff. It is well charged with boulders and smaller stones of all sizes and of somewhat varied character, though granitic materials are most abundant. A considerable proportion of the stones are strongly glaciated. The

whole thickness of the boulder-clay here exposed, shows only very faint traces of any stratification or lamination, but it includes in its mass a few lenticular, horizontal and stratified layers of sand. Overlying the boulder-clay, is a variable thickness of stratified gravels, containing a few distinctly red layers. Above the gravels, and extending to the surface, is a thickness of a few feet of earthy material, constituting the soil. This is reddish and contains some stones and boulders. It has evidently been coloured by the decomposing Tertiary volcanic rocks of the vicinity, and may have accumulated by the washing down of the material resulting from this, together with that of the surface of the drift deposits proper, under the actual conditions. The elevation of the exposures of this place is about 3500 feet above sea-level.

North Thompson Valley.

Another excellent section of the boulder-clay, which may be described as typical of its general character, occurs in the North Thompson valley near the extreme north-eastern corner of the Kamloops sheet, on Coal Brook, a mile or rather more to the east of the river and some 200 or 300 feet above it, or 1500 feet above sea-level. One bank affords a section of about fifty feet, and the boulder-clay is also shown in numerous smaller exposures. The following description is quoted from my Report of 1877-78 (p. 140 B):—

"The matrix is a very hard, bluish, sandy clay, through which stones of all sizes are scattered in every position. These are chiefly of the rocks of the neighbourhood, but include numerous fragments of granite, not seen at this spot. Many of the stones are heavily scored and a few are very large; one, a mass of coarse granite, was found to be eleven feet four inches long, by eleven feet wide, and six feet four inches deep, the last dimension not fully shown. Notwithstanding the rough, or even tumultuous aspect of the deposit, traces of bedding are distinctly seen here and there, and near the top of the section a bed of clean-washed gravel about ten feet thick occurs. Above this, the boulder-clay, with all its usual characters, resumes for a thickness of three or four feet, and is again covered by horizontally stratified and false-bedded gravels which form the upper ten feet or so of the bank."

Bonaparte, near Ashcroft.

Another excellent exposure of the boulder-clay of the region is met with at the mouth of the Bonaparte, where the river enters the Thompson, about a mile and a half only distant from Ashcroft station on the Canadian Pacific railway, and thus easily accessible. It is described in another connection on a following page (p. 273 B).

These notes on individual exposures of the boulder-clay within the limits of the Kamloops map-sheet, may suffice to characterize this deposit,

and no further mention need be made of the almost innumerable minor exposures met with in the district.

Coincidence of highest terraces and highest boulder-clay.

In the paper published in the Transactions of the Royal Society of Canada, to which reference has already been made, the general result of the investigation of many parts of the interior of British Columbia is thus given :— "Throughout the Interior Plateau the upward limit of the boulder-clay is found at a height somewhat greater than 5000 feet above the present sea-level, and corresponding in this respect with the highest level of well-marked terraces ; the higher terraces in fact generally consisting of material identical in character with that of the general covering of boulder-clay, or so closely alike as to be indistinguishable from it. Though, as previously noted, travelled stones occur on much higher points, no boulder-clay, and very little fine drift material of any kind, has been found above the highest terrace-level above referred to."*

Possible causes of this.

Various explanations may be offered of the general fact thus stated. It may be supposed, for example, that the boulder-clay by reason of its increasingly arenaceous character at higher levels ceases to be recognisable as such above a certain line, or that the naturally greater effect of denudation on the higher points has, in process of time, removed such deposits of boulder-clay as may at one time have occurred on them. As it is intended here merely to present the facts themselves, as clearly as may be from the evidence afforded by the area of the Kamloops sheet, no discussion of these or other hypotheses will be undertaken. It may be stated, however, that the proximately exact coincidence of the upper limit of the boulder-clay with the highest of the well marked terraces of the region, is apparently such as imply a common cause. No distinct boulder-clay has been recognized above the level of these higher terraces, and the main mass of the drift deposits of all kinds lies below it. As we have already seen, these deposits do not increase progressively in volume as we descend, but they are found in their greatest and most connected spread at levels between about 5000 and about 3000 feet.

Terrace-levels composed of boulder-clay.

It appears reasonable to consider the wide-spread and nearly horizontal deposits of boulder-clay which frequently occur toward the higher limit of the main drift, as essentially of the character of terrace-flats, and as probably evidencing the contemporaneous or subsequent action of water, in the same manner as do the narrower terraces. Such flats are in fact often covered by a few feet of fine silty or earthy deposit, which seems to imply sedimentation of a comparatively tranquil

*Loc. cit., p. 36.

character, as a last event. Instances of such high-level flats of boulder-clay have already been cited.

Character of upper limit.

It now remains, to describe the essential features of some parts of the upper level of the main development of drift deposits, by way of illustration of the character of this limit, and with special reference to the boulder-clay. It is, however, unfortunately not possible in all cases to ascertain the precise character or composition of the drift towards its upper limit, because of the infrequency or obscure character of the natural exposures, rendering a complete knowledge of the facts impossible and preventing a perfectly definite classification. It is also necessary, in so doing, to forestall in part what is subsequently said on the question of terraces.

Green Timber Plateau.

The general surface of the Green Timber plateau, ranging in height from 3800 to 4000 feet, is thickly and very uniformly covered by boulder-clay, this in many places forms the actual soil, but is elsewhere covered by a limited depth of sandy deposits and is traversed also by moraine ridges (p. 279 B). The character of this boulder-clay, which is quite normal, is very well shown in numerous borrow-pits along the wagon-road. The plateau rises very gradually to the west, toward the Marble Mountains, all the higher parts of which consist of almost perfectly bare rock, but of which the entire base, with a length of fifteen miles, is thickly heaped with drift deposits. As viewed from any part of the plateau at a considerable distance, the upper line of these deposits appears to be perfectly definite and straight and is very strikingly outlined.* On approaching the southern part of the range, near the upper parts of Clinton and Sandy creeks, the boulder-clay becomes covered with sandy deposits, some miles before the actual base is reached, at a height approximating to 4500 feet. These deposits increase in importance, till near the base of the mountains they appear as horizontally stratified terrace-flats, fifty feet or more in thickness as shown in the banks of Sandy Creek. Above this, are still higher, though narrow, terraces which were distinctly traced at this place to an elevation of about 5500 feet. Morainic mounds and ridges, showing gravelly material and some boulders on their slopes but not seen in section, are associated with these higher terraces, in such a way as to show that the terraces are of later date and have been formed in part by the levelling and redistribution of material derived from the moraines.

Southern part of Marble Mountains.

Northern part of base of mountains.

The northern part of the same base of the Marble Mountains, was examined to the south-west of Big Bar Lake. The plateau here rises

*Compare the sketch of Il-ga-chuz Mountain, much further north, Quart. Journ. Geol. Soc., vol. XXXIV., p. 109, Fig. 5.

somewhat less gradually toward the base of the mountains, and the conditions observed were not absolutely identical with those in the first-described vicinity. The height of Big Bar Lake is 3630 feet, and about its upper or southern end, moraine ridges are observable to a height of about a hundred feet above it. Higher than these and nearer to the mountains, a wide sandy and gravelly terrace-flat is crossed, which slopes gradually up from a level of 4000 feet to one of about 4300 feet. Beyond this, a considerable width of moraine country is again found, in which the general direction of the ridges is parallel to the base of the range. Higher than these moraines and running back to the mountains, is a second terrrace with a height of 4700 feet. Other smaller terraces with narrow treads occur still higher, to an elevation in this place of about 5100 feet. The impression conveyed by the conditions observed here is, that the several tiers of small moraines had been produced by temporary periods of advance of a glacier-mass, which, on the whole, was shrinking back to the north-westward from the then submerged area of the Green Timber plateau.

Tranquille Plateau.

Near a local summit on the Tranquille plateau, due south of Tranquille Lake, a terrace occurs with a height of 5340 feet. This is perfectly distinct and somewhat extensive, and was seen, from a distance, to be repeated on the southern slope of Porcupine Ridge, some miles to the northward and beyond the lake. Where examined in 1889, this terrace was found to be composed of boulder-clay or identical material. In 1890, about three miles to the eastward, near the head of Watching Creek, a series of narrow but distinct terraces which can be traced for a mile or more in length, was noted. These extend in height from about 5300 to 5450 feet, and are composed, so far as could be ascertained, of rounded and sub-angular gravels mixed with earthy material, the gravel being more abundant than in most true boulder-clays. The slopes to the north of and above these terraces are but thinly and irregularly covered with drift material.

In-ki-kuh' Valley.

In-ki-kuh' Creek, which joins the Thompson from the eastward five miles above the Nicola, falls very rapidly in its lower part toward the great valley of the Thompson, but at about five miles and a half from its mouth and thence to the lake at its source, occupies a wide low-grade valley on the surface of the plateau, at an elevation of about 4500 to 5000 feet above the sea-level. The lower part of this valley opens in a flaring manner toward the Thompson, and there is no probability of its having been at any time locally stopped. The country on both sides of the upper part of the stream, is thickly covered by drift, the greater part of which is of the nature of boulder-clay. The surface of this deposit rises gradually with the slope of the valley, till just

below the lake and practically at its level (4920 feet) it forms a flat terrace-like floor. The rocky hills to the south of the lake beyond, are heaped with drift deposits to a height of about 200 feet above it (5100 feet above sea-level) and these, from a distance, show a pretty distinct upper line, which might almost be designated as a terrace-level, though it was not closely examined. The hills above this level consist of nearly perfectly bare granitic rock.

Choo-whels" Mountain.

From the extensive development and wide spread of deposits of boulder-clay to the south of Choo-whels' Mountain, and the gentle slopes of the mountain itself, it was hoped that some definite information as to the precise upper limit of the boulder-clay might there be obtained, but this hope was not realized. The mountain was ascended on the south-west side and descended on the opposite slope. The highest distinct and wide terrace was passed over in ascending at 4240 feet. This is composed of boulder-clay with a silty covering, sometimes not more than two feet in thickness. True boulder-clay was noted, where the roots of trees had been overturned, for some distance above this, but at heights exceeding 5000 feet, a great part of the whole surface consisted of solid rock, with small intervening drift-filled hollows and valleys. The stones here contained in the boulder-clay are, as usual, more or less distinctly rounded, but become increasingly angular at higher levels. Toward the summit, where occasional exposures are found of the superficial deposits, these consist of earthy materials mingled chiefly with angular stones of proximately local origin. The actual south-western summit-point of this prominent elevation on the plateau, has a height of 6000 feet. It is partially covered with drift of the character just described, and the rock-surfaces, though much weathered, have been heavily glaciated. The faces which still showed the original striation, indicated (as previously noted) a direction of S. 35° E.

Heavy drift unusually high on Sil-whoi'-a-kun Plateau.

The most notable exception to the general rule of the extreme paucity of drift deposits above a level which approximately coincides with the 5000-foot contour, is found in the Sil-whoi'-a-kun Plateau. The wide elevated portion of the plateau to the west of the North Thompson so named, is more thickly covered with drift material than any other region of equal height which has been examined. The drift is moreover pretty uniformly spread upon its surface. There is, however, reason to believe, from the very frequent outcrops of rock, the generally local character of the boulders and the hard bouldery beds of the small streams and rivulets, that it is rather in consequence of the uniformity and the undenuded state of the drift material than to its thickness that its apparent importance is attributable. This again

doubtless depends on the wide surface of this higher part of the plateau. As to the precise character of the drift covering here, no very satisfactory information was obtained, as it was seen only in the upturned roots of trees. These showed a yellowish earthy and sandy material, packed with stones, which are commonly angular, and largely fragments of the subjacent rocks. Travelled stone and boulders, generally of gray granite, are also, however, scattered over all parts of this elevated volcanic plateau. The particular mention accorded to Sil-whoi′-a-kun, is chiefly for the purpose of noting its somewhat exceptional character, as compared with that of the numerous other places upon which the general statements before made are based.

Paucity of boulder clay in lower valleys.

The foregoing details refer especially to the character and elevation of the boulder-clay at its upper limit. It appears probable that the higher parts of the district were never covered with true boulder-clay. In whatever manner the boulder-clay was produced, it seems reasonable to suppose that in the lower parts of the district a thickness at least equal to that found at intermediate elevations must originally have been laid down, and highly probable that such lower tracts received an even greater mass of this deposit. As a matter of observation, it is found that exposures of boulder-clay are comparatively seldom met with in the lower and larger valleys of the Fraser and Thompson, included in the Kamloops sheet. This is no doubt in part due to the great development of newer terrace deposits in these lower tracts, but only in part, for very numerous and often almost continuous sections occur that are cut down to the solid rock along the rivers and their tributary streams. Further, with the exception of those parts of the larger valleys which are occupied by terrace accumulations, the slopes of these valleys are not usually thickly covered with drift deposits of any kind, and projecting points and large surfaces of rock are everywhere abundant.

Its removal thence by denudation

From these circumstances, I believe we are warranted in concluding that the greater part of the boulder-clay which must have been deposited in these lower valleys, was at a later period removed by denudation. On referring to what has been said in the introductory part of this portion of the report, (p. 251 B) it will be seen that I am inclined to regard this epoch of denudation as contemporaneous with, and as the result of, a considerable reëlevation of the land, which is also supposed to have been synchronous with the second period of increase of glacier ice. It is believed that the height at that time attained by the land, was such as to enable the larger rivers not only to reëxcavate their valleys, but also to remove great quantities of new material which would

doubtless be carried into them from the adjacent slopes by tributary streams and by superficial agencies.

Observed sections in Fraser and Thompson Valleys.

Without, however, insisting on the accuracy of this interpretation, I may now explain the nature of the facts upon which it is based. Of these, the most obvious, is that already referred to, *viz.*, the evidently small importance of the deposits of boulder-clay now remaining in the lower valleys. While it is probable that traces at least of this material may exist in that part of the length of the Fraser Valley which is included by the map, I am unable to mention any single exposure in which it is shown, and it was in connection with the examination of this valley, in 1889, that its notable absence first became apparent. In the Thomson Valley, between Kamloops Lake and the confluence of that river with the Fraser, while boulder-clay is scarce, it is not altogether wanting. Near Black Cañon, three miles and a half below Ashcroft, typical boulder-clay is seen in several places in cuttings along the railway, and considerable exposures are found about the mouth of the Bonaparte, a mile and a half above Ashcroft. These are the only occurrences actually noted, though close search along other parts of the valley would doubtless result in the discovery of others.

The denudation of inter-glacial date.

Granting, therefore, that the greater part of the mass of the boulder-clay originally deposited in these valleys has been in some way removed, and of this the evidence appears to be conclusive, it remains to assign a date for this removal relatively to the other phenomena of the glacial period. It might be suggested that the clearing out of these valleys occurred during the period of considerable elevation of the region which there is good reason to believe supervened at the close of the glacial epoch, and was thus merely a part of the post-glacial valley erosion which is subsequently alluded to. The occurrence and relations, however, of the White Silt deposits (also referred to in greater detail on a later page) in many parts of these valleys, negatives this supposition, and shows that the removal of the greater part of the boulder-clay must have occurred previous to the deposition of these silts, the origin of which is clearly glacial, and the period pretty distinctly that of the decline of the second maximum of glaciation. This conclusion follows so obviously from the general circumstances, that it was arrived at and used as a basis of reasoning in my paper in the Transactions of the Royal Society of Canada already referred to. Since that paper was written, additional evidence of the same kind has been met with, of which two instances may now be particularly noted.

The first of these, is that afforded by the sections shown in bluffs on the north side of the Bonaparte at its confluence with the Thompson, of which a diagram is here presented. The bluff rises to a height of

Section on Bonaparte showing this.

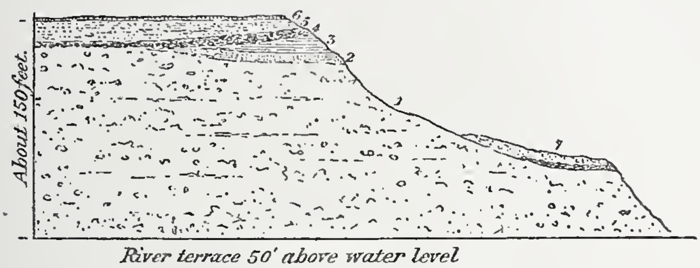

FIG. 10. SECTION ON THE NORTH SIDE OF THE BONAPARTE, AT ITS MOUTH.

1. Boulder-clay.
2. Stratified gravel.
3. White silt.
4. Old river-bed.
5. Stratified gravels.
6. Silty soil.
7. Second old river-bed, covered by stratified gravel.

about 200 feet above the river, its upper limit being formed by a terrace-flat of about that height. Of its lower part, about 50 feet is concealed by a late river-terrace, but most of the remaining height of 150 feet is well exposed. The greater part of the entire section here consists of boulder-clay. (1) This is of the usual character, containing some large boulders and many smaller stones, and is so hard as to stand in vertical faces. It includes, however, layers, some of which are two feet in thickness, of hard, silty material, horizontal or proximately so, and lenticular, not exceeding a few yards in extent. There are also similar traces of local horizontal bedding afforded by occasional sandy layers separating the general mass. No. 2, the deposit capping the boulder-clay, is a stratified gravel, composed of medium-sized and small stones like those in the boulder-clay, but more perfectly rounded. The upper part of this bed is a clean gravel, but its lower part is clayey from included material of the boulder-clay paste, and it is in consequence not always easy to fix the exact line of junction of this deposit with the boulder-clay. No. 3 is typical White Silt, with the usual creamy tint of this deposit, well and regularly stratified in thin layers and rather hard, though it may be crumbled easily between the fingers. Overlying this is No. 4, a coarse, gravelly and bouldery river-bed deposit with well rounded and polished stones, indicating a strong current, and precisely resembling the material of the bed and beaches of the adjacent part of the Thompson. No. 5, consisting of finer stratified gravels, overlies this, and gives to the surface of the terrace-flat its level form. Resting on No. 5, and forming the actual surface of the terrace, is a thin layer of silty soil. At No. 7,

Position of White Silts.

occurs another thin deposit of river-bed material like No. 4, again covered with gravels like No. 5.

The sequence of events indicated by the section thus described is believed to be as follows :—

Events indicated by sequence of deposits.

Subsequent to the deposition of the boulder-clay, this material was greatly denuded and in large part worn down, and the resulting débris removed. This action was brought to a close by a following submergence, during the progress of which, and while some parts of the boulder-clay were still exposed, stratified gravels (No. 2) were formed. With an increased depth of submergence, the deposition of the White Silts (No. 3) began and a great depth of material of this kind, was laid down, implying a prolonged tranquil period. In this particular section, merely a feather-edge of the White Silts has been preserved, but on the opposite side of the Thompson a similar material forms a considerable part of the entire height of the bank, without any apparent boulder-clay. (p. 306 B.) Similarly, about a mile further up the Thompson on the same (west) side with the section here particularly noted, the silts form a range of cliffs along the river about 350 feet in height. The material found here is not however all silt, but includes numerous beds of gravel due to inwash from the adjacent hills or streams, and resembling in character the gravel (No. 2) in the section. At a still later date, the flooded condition of the valley ceased, and the White Silts themselves became subject to erosion by the river, which resumed its course. This was doubtless in post-glacial times, and the river deposit (No. 4) represents the old bed of the Thompson, at one stage in its descent through the glacial material to its actual level. The overlying gravels (No. 5) are those of a flood-plain of the river at a slightly subsequent date, while the silty capping is a still later deposit on the same flood-plain, produced at a time when the river seldom attained to its level. The deposits at No. 7, represent part of the bed of the river at a still later stage in the process of post-glacial erosion, when it had cut down about a hundred feet lower than the level of No. 4.

Silts and Gravels.

Post-glacial erosion.

The most important point illustrated by this section, is of course the relation of the White Silts to the boulder-clay and to the interglacial period of denudation, on one hand, and to the much later post-glacial erosion on the other.

Conditions in Tranquille Valley.

A second illustrative case, is afforded by the conditions of the lower part of the Tranquille River, though in this instance the whole series of events is not so clearly shown as in the last. The Tranquille River, above the point at which it debouches on its wide delta-flat, flows for several miles in a deep cañon-like gorge or narrow trench, cut out along

the axis of a much wider valley, of which the bottom-level, at some miles back from Kamloops Lake, has a pretty uniform height of about 800 feet above that lake. The newer and narrow valley, has been completely filled with drift material referable to the period of deposition of the White Silts, and in post-glacial times has been reëxcavated by the stream, which has even been able to cut to a small additional depth into the rocky bottom of the old valley. The drift material referred to, still, however, remains in some parts of the narrow valley, in the form of steep banks or cliffs, in height nearly equal to the whole depth of the gorge. It consists principally of firm beds of gray gravel, but these hold important intercalations of White Silt of the usual character, and quite distinctive enough to fix the date of the deposit as that of the White Silt formation generally. The gravelly character of the beds at this place, is in fact evidently due to the local supply of coarser materials washed down into the body of water in which the silts were in course of deposition, a circumstance frequently observed elsewhere.

Excavation subsequent to boulder-clay.

No true boulder-clay was met with in this narrow part of the Tranquille Valley, but it cannot be doubted that if the gorge existed in pre-glacial times it must have been filled with boulder-clay, and that this was worn out subsequently by the stream during the time intervening between the period of the deposition of the boulder-clay and that of the White Silts. If, on the other hand, it be supposed that the gorge is not pre-glacial, but was cut out in the rock during the same intervening time, it equally implies that this was one of considerable elevation, and would tend to show that it was even more important and longer continued than it would be necessary to believe under the first and more probable hypothesis.

Cones of dejection in larger valleys.

Another circumstance, which may be mentioned in this connection, is the occurrence in several instances along the Thompson and Fraser, of noteworthy accumulations of heavy boulders, opposite the mouths of some of the tributary streams and forming true cones of dejection at these places. It is difficult to determine at precisely what epoch these accumulations were formed, but their relations lead me to believe, that this happened at a time previous to that at which the greater part of the terrace-material now occupying these valleys was deposited, and under circumstances in which, though excessively heavy flood-waters were occasionally discharged by the tributary valleys, the main valleys were not themselves river-courses. To comply with the last-mentioned condition, it is obvious that the lower and larger valleys must have been deeply flooded, and it is therefore highly probable

Their date.

that the boulder-cones were produced after the time of the main denudation of the boulder-clay in these valleys, and during the earlier stages of the following submergence which resulted in the accumulation of the White Silts.

On Thompson River.

The most instructive case of this kind noted, is that on the Thompson four miles above Spence's Bridge, opposite the mouth of Pimainus Creek. The Thompson Valley is here excavated in Tertiary volcanic rocks, while the material brought down from the valley of the Pimainus is almost entirely granitic, and is thus easily recognized. The cone of dejection has here evidently spread from the mouth of the Pimainus, quite across the wide valley of the Thompson, to the bases of the mountains on the opposite or west side. In following the wagon-road on that side, the great accumulation of heavy granitic boulders, in some cases at least six feet in diameter and massed together at a height of 200 feet or more above the present river, is very notable. What still remains there of the outer part of the cone, is now, however, separated from the east side of the valley by the whole width of the later immediate valley of the Thompson, and in being cut through at this later time by the river, it has been made to assume the form of rough, bouldery terrace-flats. On these, the thickly strewn boulders have been rounded, worn and polished, while the river flowed at their level, and before it had succeeded in reëxcavating its bed to its present depth. During this process of reëxcavation the river has carried granitic material derived from the old cone along its course, and in following the river down, this material is found to decrease gradually in amount and in the size of its constituent fragments.

On Fraser River.

At the mouths of Ni-kai-a and Kl-ow'-a creeks, below Lytton on the west side of the Fraser, similar cones of dejection containing some very large boulders were noted. The mountains in which these short streams rise, consist of granitic rocks, which break up with facility into boulder-like masses, but no flood-water ever now occurring will account for the carriage of such large masses as those which have been brought down under former conditions. It is probable, that these and other similar cones of dejection along the Fraser, are referable to the same period with that above described. Some further allusion is made to such cones and 'fans' in connection with the history of the Fraser Valley (p. 303 B).

Terraces and Stratified Deposits newer than the Boulder-clay.

Interlocking of phenomena.

Under the last heading, particular attention has been given to the boulder-clay, with the facts bearing on its limit in elevation, or ex-

plaining its relative scarcity in the lower and larger valleys, in which, other things being equal, we might reasonably have anticipated that it would be found in its greatest development. The various phenomena of the glacial period are, however, so closely interlocked, that in following the subject of the boulder-clay it has been necessary to introduce the consideration of some other topics, and in part to anticipate, by allusion to them, some of the deposits which are considered in greater detail in following pages. A strict separation of the different parts of the subject, could be arrived at only by the adoption of some ruling hypothesis, which in this description of the phenomena it is my purpose to avoid as much as may be possible.

The list of terraces.

The more important terraces observed in the area of the Kamloops sheet are enumerated below. The observations are given in the order of their height, beginning with the highest, and it may be explained that the terraces here mentioned, unless otherwise stated, are believed to represent old shore-lines. The higher terraces which appeared to be of this character were carefully noted, but those which could be explained on the spot as being due to strictly local causes, such as local moraine dams in small valleys, and the valley-terraces of streams running upon the plateau, are not included. Neither are the river-terraces of the larger and lower valleys here enumerated, though terraces of this class continue to occur at all levels in the district below those with which the present list terminates. After descending to a certain level in these lower valleys, it became difficult to discriminate between terraces representing shore-lines proper, and which may either have been cut out in preëxisting drift deposits or built up by inwash from the adjacent slopes along a shore-line, and those which have been produced by the actual rivers while these were engaged in reëxcavating their valleys in post-glacial times. The terraces of the latter class have a meaning of their own, in relation to the later history of the rivers. The list which follows, scarcely includes any of the low-level terraces, which form such a striking feature of the scenery of the Fraser and Thompson valleys, and cannot escape the notice of the traveller who may pass through the district on the line of the railway. They have been observed under varied conditions, being sometimes clearly seen for miles at a time, on open grassy slopes along the edges of parts of the plateau, at others crossed in dense woodland or found patched upon the more prominent summits of the plateau or mountains adjacent to it.

Lower-level terraces not included.

Different values of terraces.

It is, therefore, not possible to ensure that all the observations are of a strictly comparable character, for while in some places such terraces may have but a narrow tread, and are, therefore, susceptible of

definition in regard to height with considerable accuracy, other cases occur of wide terraces sloping gradually back from a frontal edge, which may now be imperfectly defined, to a considerably higher level. Besides these here particularly enumerated, there are also many faintly impressed water-lines locally preserved, and often apparent from a distance on open slopes, particularly at elevations inferior to 3000 feet. An easily accessible example of this kind, which enables the lowering of the water-level by a uniform process, or one with but short stationary intervals, to be traced, is found on the north side of Paul's Peak, near Kamloops. On this grassy slope, under favourable conditions of light, a complete descending scale of such small terraces may be seen.

Heights barometrically ascertained.

The heights given below have been barometrically determined within small limits of error, by comparison with a station barometer at Kamloops, the reduction of the various observations having been made in the same manner with that of those upon which the contour-lines of the map depend.

List of the higher Terraces observed within the area of the Kamloops Sheet.

	Feet above sea-level.
1. East side Marble Mountains, north of Clinton Creek (p. 268 B)	5500
2. Near head of Watching Creek valley (p. 269 B) 5300 to about	5450
3. Slope of Mount Murray, a small and irregular but still distinct terrace	5380
4. West side Marble Mountains, twelve miles north-west of Kelley Lake, about	5360
5. South-east side Lytton Mountains, apparently a distinct terrace-flat on slope of Fraser Valley	5340
6. On plateau near Tranquille Lake (p. 269 B)	5340
7. East side Marble Mountains, north end, near Big Bar Lake (see No. 9) about	5100
8. Head of Big-fish Lake, Greenstone Creek. A small terrace, which may be due to local ice-damming or moraine-damming of the valley	5000
9. East side Marble Mountains, north end (p. 269 B), same locality as No. 7	4700
10. South of lower part of Meadow Creek	4700
11. Murray Creek. Terrace in valley, doubtfully due to local causes	4450
12. Point of plateau between Meadow Creek and Guichon Creek. Well marked wide terrace, of which the surface shows evidence of current-action contemporaneous with or subsequent to its formation. Direction of current indicated S. 50° E (See p. 293 B)	4400

	Feet.
13. Plateau between head of Skuh'-un Creek and Mamit Lake. Terraces associated with moraines	4396
14. Valley of Ray Creek, a tributary of Guichon Creek..	4350
15. Meadow Creek valley, north side, near mouth of Greenstone Creek, about..........................	4350
16. In-ki-kuh' Creek. Terrace-flat (p. 269 B)...........	4330
17. Western slopes of Trachyte Hills, near Hat Creek...	4300
18. Plateau west of Trout Lake. Terrace-flat composed of boulder-clay..................................	4240
19. Plateau between heads of Guichon and Three-mile creeks. Distinct terrace	4150
20. Green Timber Plateau. Sandy terraces and terrace-flats between morainic ridges................	3900 to 4150
21. Highland Valley near watershed. Terraces several hundred feet above moraines in valley..............	4000
22. Guichon Creek valley, west side, below Witches Brook. Terraces traceable for several miles, about..........	4000
23. East base of Marble Mountains, north end. (See No. 9.) Wide terrace-flat sloping gradually down from moraine ridges at 4300 feet to................	4000
24. Point of plateau between Pukaist and In-ki-kuh Creeks	3730
25. Guichon Creek valley below Witches Brook, west side. Terrace traced several miles at lower level than, but in part overlying, moraine ridges. A second development of moraine ridges at lower level, between this terrace and the creek...........	3590
26. Dome Hills, near Kamloops.......................	3500
27. Hat Creek valley, west side, near east end Marble Cañon. Wide terrace. (See No. 32)	3360
28. Upper Guichon Creek, above Witchos Brook. Terraces and contemporaneous moraines...............	3350
29. Lower Guichon Creek, below Mamit Lake. Terraces and moraines, about...........................	3250
30. Ridge east of Paul's Peak. Large flat drift-covered area..	3250
31. Lower part of Upper Nicola valley, near lake. Terraces rather faintly impressed but traceable for many miles. (See No. 39).........................	3080
32. Hat Creek valley, west side, near east end Marble Cañon. Wide terrace below No. 27................	3070
33. South of Jacko Lake, about......................	3050
34. South of Jacko Lake..............................	3000
35. One mile west of Jacko Lake. Terrace-flat......	2790
36. Near Newman's, Trapp Lake. Wide terrace........	2580
37. Twaal Valley. Terrace composed of silty material...	2500
38. Nicola Valley, at lower end of Nicola Lake. Best marked of several terraces.......................	2470
39. Lower part Upper Nicola Valley, near lake. Important terrace of same series with No. 31..........	2450
40. Inner Valley, near Kamloops. Highest terrace locally recognized....................	2400

Comparison of terraces.

An inspection of the above list of observed terraces or shore-lines, will show that these occur, within the area of the Kamloops sheet, at many different levels from a height of 5500 feet down. The list might doubtless be largely added to by further and more minute examination of the area in question, but the actually recorded observations are sufficient to indicate the general character of the facts as they occur there. Considerations already referred to, render it impossible to institute any very exact comparison between the heights of terraces in different parts of the field, and in order to investigate the questions which might be found to depend on such comparison, it would be necessary to spend much time in following out individual terraces, in a manner not yet attempted. In order, however, to arrive at such general ideas of correlation as the observations might warrant, these were graphically represented together on a single sheet. An examination of the levels of the various terraces as thus assembed, brings out a marked tendency of the observed levels to group themselves about several points, at or near which it is to be presumed that the water stood for a longer period than at intermediate elevations. It also shows, that no very long interval in the whole scale is altogether without terraces, even when the evidence considered is limited to that obtained in the area of the Kamloops map-sheet.

Highest group.

The highest recognized terraces appear to form one such well-marked group, the observations regarded as belonging to which are those included between about 5500 and 5300 feet (Nos. 1 to 6 of list). The observations on terraces of this highest group are scattered over a considerable area of the map, and are moreover supplemented and extended to a much wider area by some made beyond the Kamloops sheet which have been elsewhere discussed.*

A few scattered observations at less considerable elevations, intervene between those included above and those of the next considerable group of terraces. Of these intervening terraces, No. 7, with a height of about 5100 feet, met with on the eastern base of the northern end of the Marble Mountains, is similarly situated to No. 1, and there is reason to believe that it belongs to the same series of terraces, which, running along the base of the Marble Mountains, overlooks the Green Timber plateau. No. 9, again occurs in the same locality with No. 7, and probably forms a lower member of the same descending series, and one for which there is no apparent reason to suppose any different mode of origin. This and that numbered 10, it will be

* Trans. Royal Soc. Can., vol. VIII., sec. IV., pp. 36, 37. See also Bull. Geol. Soc. Am., vol. VII., p. 31.

observed, are identical in height. The terraces numbered 8 and 11 may possibly be due to strictly local causes.

Notable gap in scale of terraces.

I have referred thus in detail to these observations relating to certain terraces below these which have been included in the above "first group," as preparatory to the statement that the most notable gap in the whole series of such shore-lines is that which occurs at about this place. The extent of this gap, or interval in which few terraces are known, may probably be approximately defined as occurring between 5300 and 4450 feet. In order further to illustrate the paucity of shore-lines in this interval, it may be added that, in the whole interior of British Columbia, I have recorded but three instances of terraces within the limits just stated, in addition to those above cited from the area of the Kamloops sheet. These are Mount Tod, 5116 feet, or practically identical with No. 7; Prospect Creek, 4660 feet; Dease River Valley, 4600 feet.* Of these the first is supposed to belong to the "first group," and the second is very probably identical with that represented by Nos. 9 and 10. Both these are situated but a few miles beyond the edge of the Kamloops sheet. The third is so far distant to the north-west, that no argument can safely be based on its seeming relation to the others.

Lower members of highest group.

The apparent connection of several of these "intervening terraces" with those of the rather well-marked "first group," as abnormally low members, due to the same series of events or produced in the same manner, has already been referred to. A consideration of this and the other facts above noted, and more particularly of the occurrence of the rather well-marked break in the continuity of the entire series of terraces which has been alluded to, led me in a former publication to suggest the origin of the terraces of the "first group" with the scattered lower dependant terraces, to what I have called englacial lakes, and to attribute the whole system of terraces below this break to different causes, but no further argument on this point need here be entered into.†

Second group of terraces.

A second group of terraces or shore-lines, which appears to be fairly well marked out by observations in the area of the Kamloops sheet, may be defined as running from 4450 feet to 4300 feet, embracing the entries numbered 11 to 17, both inclusive. These observations are derived from the whole valley of Guichon Creek, and parts of the adjacent plateau, the Thompson Valley below Ashcroft, and the wide upper valley of Hat Creek. The terraces included in this group are important, and are often traceable for considerable distances, but the

* *Cf. op. cit.*, pp. 36-37. † See, in this connection, foot note to next page.

lower limit, at least, must be considered as scarcely more than arbitrary, as no marked break again occurs in the descending series. Beyond the Kamloops map-sheet, within British Columbia, I know of only two instances of terraces which are included between the limiting heights given for this group, and these are too far removed by distance to be employed as any basis of argument.

Various correlations.

The succeeding terraces enumerated, from No. 18 to No. 23, both inclusive, show a general correspondence between the region of the Green Timber plateau, and that in the valley of, or on parts of the plateau adjacent to, Guichon Creek, with a marked developement of important terraces at a level of about 4000 feet.

Numbers 27 and 28, in the wide valleys of Hat Creek and Guichon Creek respectively, are practically identical (3360 and 3350 feet), while Nos. 30 and 31 in the Nicola Valley (which is freely in communication with the Guichon Creek valley) and Hat Creek valley respectively, (3080 and 3070 feet) seem to form a similar but lower pair, and to indicate similar periods of arrest in the subsiding water-line in both these rather widely separated places.

The association of some of the terraces at levels of 3350 and 3250 feet in the Guichon Valley (Nos. 28 and 29) with morainic ridges, is mentioned in the list, and though at some distance to the south of the Kamloops sheet, it may be added that in valleys and on low tracts of the plateau to the east of the Coldwater River, a similar association is found at closely corresponding elevations, or between 3300 and 3200 feet approximately.*

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* Since this part of the report was written (1893) an entirely independent reëxamination has been made of the glacial deposits of the south-western part of Alberta, to the east of the Rocky Mountains and along the western margin of the Great Plains; a district removed by nearly 300 miles in distance from that here particularly described. This has developed so striking a general parallelism between the higher terrace-levels of the two districts that it seems necessary to allude to it, although inappropriate here to enter into a discussion of the wider questions which it appears to raise, including the probability of a general subsidence of land much greater in amount than that postulated by the provisional scheme of events given in the first part of the present chapter. The main conclusions respecting the terrace-levels of south-western Alberta, may be best conveyed by quoting the following paragraph from the paper dealing with that subject:—"All the later and lower terraces and gravel plains may be regarded as marking stages in in the subsidence of this water-level from its maximum height of 5300 feet. These, it has already been noted, are usually not strongly impressed, and there is no evidence that the subsidence was arrested long, except at one stage, which is that spoken of in the report of 1882-84 as being at about 4200 feet. Further examination shows that the terraces referrable to this particular stage slope up gradually in the foot-hills, and on approaching the mountains, to a maximum height of about 4500 feet, from which it may be argued that from the last-mentioned height the water lowered its level gradually to one of about 4200 feet, while new material was constantly being washed down by rivers from the mountains. A later and still lower, though less important, period of arrest, seems to be marked by the gravel plain near Macleod at about 3200 feet." (Bull. Geol. Soc. Am., vol. vii, p. 63.)

No better examples of the lower terraces of the region (excluding river-terraces) can be found than that presented by the hills near Kamloops (1150 feet). Behind the town, particularly in an afternoon light, the grassy slopes on both sides of Peterson Creek are seen to be ruled by parallel shore-lines at several different elevations. In ascending these hills by the road, the level of one of the highest terraces in this immediate vicinity, is very clearly seen on the eastern slope of the ridge to the north, near Guerin's, where it is marked by the lower edge of the wooded growth. Its elevation is 1900 feet above sea-level, and near Guerin's house, on the road, it is found in a more or less denuded and hummocky condition, to be characterized by well rolled gravels and stones, with some sandy and earthy matter. This particular terrace is, very probably, that representing the margin of the body of water in which the White Silts of the vicinity were deposited. Examples of lower terraces

Continuing southward from Guerin's, across the hills, to the neighbourhood of Jacko Lake, higher terraces are discovered at many different levels, often occupying retired angles and valleys, but none of them by any possibility due to purely local causes. Near the small hour-glass-shaped lake to the south of Jacko Lake, the highest terraces actually seen in this vicinity were observed, at levels of about 3000 and 3050 feet above the sea respectively.

White Silt Formation.

The terraces and shore-lines enumerated in the foregoing list, and to some of which the explanations just given apply, are in part of the nature of accumulations built up along the edges of water, and in part have been cut out of still earlier drift deposits by the erosive action of the margin of the water. In many cases the information is not sufficient to determine the precise mode of origin of any particular terrace, and in some instances both processes have no doubt coöperated in producing a terrace. At levels lower than these included in the foregoing list, terraces of both kinds continue to occur, and a considerable proportion of the terraces of erosion are known to be true river-terraces, formed by the rivers and streams when engaged in reëxcavating their beds in post-glacial times. The interest attaching to these is chiefly in connection with the history of the modern river-valleys. From about the level of 2500 feet downward, a notable development of pale silty deposits is found in many parts of the area of the Kamloops sheet. These deposits have originally been much more extensive than they now are. They are sometimes still found to completely floor the valleys, but in most cases remain as terrace-like fringes along the sides of White Silt terraces.

valleys in which the river has since cut a deep median trough, and not infrequently, but small traces of the original deposit are preserved, clinging to the sides of the valleys, or occupying sheltered recesses along the bases of the plateaux.

Nature of the deposit.

These White Silt deposits are very widely developed throughout British Columbia, and their character and probable meaning has been discussed at some length in the paper which has been already several times referred to. The following general remarks on the White Silts are quoted from this paper* :— " In the regions characterized by them, which are in almost all cases at a less elevation than 2500 feet, these White Silts very often rest directly upon the boulder-clay. They are generally fine and uniform in texture and are usually well bedded in perfectly horizontal layers of an inch to two or three inches each in thickness. Where occasional sandy or gravelly layers are intercalated, these are attributable to local causes, being most frequently found opposite the mouths of valleys down which streams have flowed. * * * The silts have evidently been laid down, as a rule, in tranquil water of considerable depth, and their material has as obviously been supplied by streams or rivers discharging from glaciers not far removed. In physical characters the silts resemble the deposits of the Red River valley, though usually in the Cordilleran region paler in colour, and seldom so clayey as those of some parts of the Red River. They differ from Loess chiefly in their well-bedded character. It is believed that the general correspondence in elevation of the various and more or less separated bodies of water in which this White Silt formation was formed, in itself constitutes a strong argument in favour of the hypothesis that these bodies of water were in direct communication with the sea and were governed in their level by that which it held at the time. No traces of morainic or other barriers have been found in any case sufficient to account for the damming back of water at the requisite level, nor do the local circumstances admit the supposition that such water was held in by glacier dams. Had the silts been formed merely in lakes produced in one or other of the modes last mentioned, they might be expected to occur, in a region with such strongly marked features as that of the Cordillera, at a variety of very different levels, in correspondence with circumstances varying in each particular case. The length of the period required for the deposition of a great thickness of these fine beds, also affords reason for belief in a long epoch of stable conditions, and to some extent justifies the presumption of the proximate contemporaneity of such a stable period. On

Correspondence of levels shows common cause.

Long tranquil period.

* *Op. cit.*, p. 44.

following the silt formation toward the various mountain ranges and sources of local glaciers, it is almost invariably found to be cut off somewhat abruptly before the mere increase in elevation would account for its disappearance. This circumstance, may, with very little doubt, be attributed to the fact that during the deposition of the silts, these upper parts of valleys were occupied by the still considerable local glaciers of the second period, which were engaged in producing the material of the silts. The evidence is, further, conclusive that these glaciers in the end retreated pretty rapidly, leaving, in many cases, the long trough-like valleys which they had occupied, almost entirely free from débris or detrital matter of any kind, and ready to become the beds of fiord-like lakes."*

Relation to glaciers of second period.

The following more particular notes from the same source,† refer to the southern part of the Interior Plateau generally and in great part to the area of the Kamloops sheet :—" In the southern part of the Interior Plateau region, in consequence of the considerable height of the mean level of the country, the White Silt formation is usually confined to the various trough-like valleys. It may be seen from the line of the Canadian Pacific railway, in characteristic development, forming frayed terraces along the South Thompson valley for a number of miles east of Kamloops. It is found also along Okanagan Lake, but in the southern continuation of the Okanagan Valley, near the forty-ninth parallel, is chiefly represented by fine sands. Along the lower part of the Similkameen it has been observed in patches. On the Nicola it is often well displayed. It extends down the main River Thompson to about the mouth of the Nicola, and appears again characteristically developed along the Fraser to the west of Clinton. It stretches far up the North Thompson, and runs back along the valleys of the main tributaries of this stream as well as of those previously mentioned. The silt formation is often along these valleys a striking feature, and is shown in terraces from 100 to 200 feet or more in height."

White Silts in southern British Columbia.

"It is worthy of remark that on the lower part of the Okanagan Valley, as well as on the lower part of the main Thompson and Fraser, the silt is reduced in quantity and replaced by coarser arenaceous deposits, a fact tending to show the existence of rather strong current

Coarser peripheral deposits.

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* In 1894, a series of small deltas, with steeply sloping fronts, was observed in the mouth of a valley entering the Seymour Arm of Shuswap Lake, on the west, eight miles from its head. The highest of these was estimated to be about 500 feet above the lake, or about 1650 feet above sea-level. It existence means, that at the time the ice had almost or entirely left the lake-basins, the White Silt water still stood at the above-mentioned level.

† *Op. cit.*, pp. 45-46.

action in these main outlets of the plateau region. The silt formation is entirely absent from the upper portions of the valleys occupied by Adams Lake, Shuswap Lake with its various arms, the Arrow Lakes, and the northern part at least of Kootanie Lake.*

Silts at two principal levels.

"In previous publications I have stated the maximum observed height of the main deposits of these silts of the southern part of the Interior Plateau at about 1700 feet,† but later observations show that they are developed to a notable extent at considerably greater elevations. I will here only instance the valleys of Barrière River, a tributary of the North Thompson, Upper Nicola River below Douglas Lake, and Skuh'-un Creek, a tributary of the Lower Nicola, where thick deposits of White Silt, cut into terraces, were observed at heights of about 2250, 2500, and 2450 feet respectively. It is thus probable that we may place the upper level of the silt formation in this region at about 2500 feet, though it is still apparent that the more important developments of the deposit lie below 1700 feet. The silt deposits are found in this part of the Interior Plateau down to heights less than 1000 feet, but it is possible that some of the lower-level deposits have been secondarily formed from the denudation of the higher."

White Silt formation near Kamloops.

In my preliminary report on the Southern Portion of the Interior of British Columbia,‡ some details respecting the White Silt formation in the area of the Kamloops sheet are given, together with a discussion of the mode of origin of the deposit. From this source the following passage may be quoted in further explanation of the mode of appearance and character of the silts, the special reference being to one of the main developments of the formation at about the level of 1700 feet:—
"In the valley of the South Thompson, the silt formation is most characteristically represented, forming as before stated, broad terraces or benches along the sides of the valley, with the surfaces gently sloping towards its axis, where the river has formed for itself a deep subsidiary channel. In some places—as above Kamloops on the south side of the valley—the edge of the White Silt bench has been cut up by little streams descending at times from its summit, into complicated and ragged ridges. The eroded faces are always very steep, and occasionally vertical, and in the sunlight have a peculiar glossy shimmer, due to the great abundance of minute particles of mica, which, when the bank is wet, become arranged parallel to its surfaces and on drying adhere in that position. The bedding is generally almost or quite hori-

*The southern portion of this lake has not yet been examined.

†Report of Progress, Geol. Sur. Can., 1877-78, p. 143 B. Quart.Journ.Geol. Soc., vol. XXXVII., p. 275.

‡Report of Progress, Geol. Surv. Can., 1877-78, pp. 142-144.

zontal and layers of a few inches in thickness succeed one another with great regularity. The deposit is remarkably fine thoughout, and no boulders or stones so large as to imply the action of ice were seen. A short distance below Little Shuswap Lake, the silts appear in a bank about sixty feet above the river, but beyond this are not again met with (to the east) nor were they recognized on any part of the shore of the Great Shuswap Lake."

Gravelly intercalations.

The occurrence of silts interbedded with gravels of local origin, in the valley of the Tranquille, has already been referred to in another connection (p. 274 B) and so has the remarkable display of interbedded silts and gravel on the Thompson some miles above Ashcroft, where such deposits form cliffs 359 feet in height (p. 274 B and Fig. 14, p. 306 B.) Similar interbedded silts and gravels are displayed near the mouth of Cherry Bluff Creek on Kamloops Lake, where cliffs, worn into columnar forms, show well stratified and rounded gravels, hard packed, for a thickness of twenty feet or more. Above these is about fifteen feet of typical White Silt, finely bedded in horizontal layers and sometimes holding flattened calcareous nodules. The White Silts are again well exposed in high bluffs or cliffs on the line of the railway following the Thompson between Black Cañon and Spatsum station.

Change to sands on lower Thompson.

In illustration of the coarser character of the silt deposits and the manner in which the typical development of silts dies away on the lower Thompson, the following notes are given:—The silts are seen fairly well developed about the mouth of the Nicola River and Spence's Bridge, and for a few miles beyond. But further down, below the mouth of the Nicoamen River and between that place and Lytton, the scarped banks in which silts might be expected to appear, show instead bedded coarse sands and gravels, with lenticular beds of pale fine sands and only occasional similar beds of silt. These finer beds are well marked and occur at a height of several hundred feet above the river a couple of miles above Lytton on the old wagon-road. They are in general horizontal or nearly so. These deposits, as a whole, appear thus gradually to replace the typical White Silts in descending the river, but it is possible that they may consist of rearranged material of somewhat later date. It is probable also, that in this narrow part of the valley, much of the material has been immediately derived from the wash from the slopes of the adjacent hills.

Shore-lines of water.

The discussion of the White Silt formation naturally allies itself closely with that of the terraces and shore-lines, for the body of water in which the silts were gradually laid down must, obviously, have left some such marginal traces. It is further, however, obvious that the littoral de-

posits of such a body of water would probably not be silty, but rather of the nature of sand or gravel, and that the correlative terraces, whether of erosion or accumulation, cannot be expected to show in themselves, by their character, their connection with the period of formation of the silts. In endeavouring to arrive at the height held by the water at this time, it is moreover plain that the highest parts of the silt deposits are alone capable of giving definite information, as the accumulation of the silts may have gone on in some places in water of considerable depth.

Relation to terraces.

The heights at which the silts are found, appear to render it probable that some of the lower terraces enumerated in the list already given, may actually be connected with levels held by the body of water in which the White Silts were laid down. The five last terraces of the list (Nos. 36 to 40) may particularly be suspected of standing in this relation to the White Silts, but in one case only (No. 35) is the terrace-flat itself actually formed of silt.

Special conditions in Southern Interior.

The relative abundance of sometimes faintly impressed but yet well preserved shore-lines, at heights below that of the higher of these terraces (near to or below the upper limit of the White Silt formation), seems to accord with the date to which this formation must be assigned, which is that of the latest phenomena of the glacial period and attending its close. The circumstance, in the southern part of the Interior Plateau that the White Silts occur at or about the general upper level of the similar deposits found very widely throughout the northern Cordillera,* while at the same time their maximum development is locally confined to elevations below 1700 feet, though no such important development is noticed elsewhere at a well marked stage below the maximum level, requires explanation. It is believed to indicate a partial elevation of the corresponding portion of the Interior Plateau, during the period of deposit of the White Silts, which was local in its character and did not affect other portions of the Cordillera.†

Heights of White Silt.

The following is an enumeration of the principal observations of the height of the upper surface of the White Silt formation, obtained in the

*Cf. Trans. Royal Soc., Can., vol. VIII, p. 49.

†It appears to be quite possible that the shore-lines lately traced in central Washington by Mr. I. C. Russell, at a horizon of about 1400 feet above sea-level, may represent a further extension (with less considerable depression) of the White Silt formation. Mr. Russell attributes these to a hypothetical "Lake Lewis," but admits that they may have been produced at sea-level in consequence of a subsidence. The suggested correlation will not hold, however, if Mr. Russell is correct in making the date of these southern shore-lines correspond with that of the maximum of glaciation. Should it be found to hold, I would still propose to employ the original designation here used for the deposits, by which their unity and synchronism throughout the northern Cordillera is implied. (See Bull. U. S. Geol. Survey, No. 108, pp. 26-27.)

southern part of the Interior Plateau. Several of these are contained in the Kamloops sheet, but for the purpose of making the evidence more complete, some are quoted from adjacent regions. These last are named in italic letters in the list :—

		Feet.
1.	*Upper Nicola Valley*, between Nicola Lake and Douglas Lake	2500
2.	Valley of Twaal Creek. White silty material flooring the valley to about	2500
3.	Skuh'-un Creek, Nicola River, bluff of White Silt, about	2450
4.	Venable Valley, near Thompson River. Silty flat, flooring the valley. Lower central part 2230 feet, sloping up to	2280
5.	*Barrière River*, near the lake. White Silts seen at intervals along the valley, and may occur somewhat higher than figure	2250
6.	*Grande Prairie.* Silty terrace, overlooking the lower plain which appears to be composed of rearranged silty material	2230
7.	*Valley of Scotch Creek*, Shuswap Lake. Terraces of fine sandy material passing into silt and very probably connected with the White Silt formation	2220
8.	Botanie Valley. Upper and higher part of a large flat which floors the lower part of this valley. The material of this is largely silty, and like the last it apparently represents a local marginal development of the White Silts at a certain stage	2070
9.	*White Valley*, west of Okanagan Lake. Highest observed level of silty terrace or plateau	2000
10.	Notch through which trail leading from Spence's Bridge to Twaal Valley passes. Flat terrace-level filling valley between the hills and composed of silts	1830
11.	*Valley of Deep Creek*, Okanagan Lake. Wide terrace-flat containing much silty material, but also sometimes sandy and occasionally stony. Supposed to represent the upper level of silt deposits about this place	1840
12.	*Valley of Okanagan Lake*, north of Deep Creek. Terrace-flat composed of White Silt. This is the highest typical silt terrace noted along Okanagan Lake, but the deposits extend in some places down to the lake level (1150 feet).	1730
13.	*Flat about summit level* between Salmon Arm and outlet of Great Shuswap Lake. This is crossed by the Canadian Pacific railway, and is composed to a considerable depth at least of silts, which are not so pale-coloured as usual. Average highest level	1708
14.	General highest level of extensive silty deposits found about Kamloops and eastward. The edge of the deposit here appears to be marked by a beach at about 1900 feet. See p. 283 B	1700

Separation of White Silt formation from other silts.

It is of course impossible to exhibit in detail or describe completely the circumstances which have led me to regard the White Silts as a distinctive and important member of the glacial series. The appearance

of these deposits in the field, and their restriction, in mass, to certain levels of the country, appear to justify this view if we speak alone of the Kamloops sheet, and without reference to the wider developments of White Silts elsewhere found in British Columbia. Deposits of a silty character, however, occur in minor development, and in consequence of circumstances more or less strictly local, at various higher elevations, and thus the mere occurrence of such deposits taken without reference to other considerations, is not diagnostic.

Silts of Highland Valley.

The only occurrence of silts in mass and forming entire, though low, terraces distinctly above the general maximum level, in the area of the Kamloops sheet, is one met with in the Highland Valley. The silts developed at this place are quite local, and appear in that part of the valley which drains north-westward to the Thompson River, at a level somewhat less than 4000 feet above the sea. Small moraines are also found in this valley, of such a character as to show that a tongue of ice occupied it and pushed south-eastward in it at one stage in the decline of the general Cordilleran glacier. It is supposed that a glacier-lake was here formed between the front of the ice-tongue and the watershed in the valley, in which a certain development of silts took place before it was drained (p. 301 B).

Silts of Louis Creek Valley.

The upper valley of Louis Creek, a short distance beyond the Kamloops sheet to the eastward, apparently affords another case similar to the last and explicable in the same way, which may be briefly referred to because of its bearing on the general question. This deep valley again slopes in a northerly direction, the stream rising only a short distance from the north bank of the South Thompson, from which river the valley may be entered by a somewhat remarkable notch in the plateau. In the upper part of the Louis Creek valley, rather important and well marked silty terraces, through the material of which a certain amount of angular rock-débris is scattered, reach up to 3460 feet. This is approximately the height of the notch above referred to, and there is every appearance to show that through this notch a large stream at one time flowed. This could only have occurred when a tongue of the retreating glacier still filled the lower and northern part of the Louis Creek valley, precluding the northward flow of the water, and producing a glacier-lake in which the silts are supposed here to have been locally deposited.

A glacier lake.

Similar occurrence on Hat Creek.

While speaking of such local glacier-lakes, it may be mentioned that it appears to be probable that still another of a similar kind was at one time produced in the same way at the head of the Hat Creek valley. A considerable stream draining this temporary lake seems to

have flowed out by way of Jack's Creek to the Bonaparte, and to have been largely instrumental in giving its present appearance to the Limestone Amphitheatre on Jack's Creek. No remarkable development of silty deposits was, however, noted in this place.

Date of these lakes.

If such local occurrences of silts at high levels as those just alluded to, be referred to the period of the retreat of the main glacier, it will be observed that they must antedate the main White Silt formation, previously described. It may also be noted in passing, that the elevations at which the waters of the glacier-lakes of Louis Creek and Hat Creek valleys flowed out into different parts of the Thompson Valley, show that any general flooding of the country which may have followed the retreating ice-sheet, can not, at the times of existence of these lakes have progressed to a greater height than that of their outflows, or about 3460 and 3900 feet respectively.

It is of course possible, that such glacial lakes may have been produced by glaciers of a relatively local character during the maximum of the second period of glaciation, and if so that the silts of Highland Valley and Louis Creek valley may be contemporaneous or nearly so with those of the main deposit.

A reference to an earlier page of this part of the Report (p. 252 B) will sufficiently indicate the mode in which the White Silt formation is supposed to have been produced, and the relative position which it is believed to hold in the sequence of events of the glacial period.

Drumlin-like Ridges.

Within a certain area of the Kamloops map-sheet, as well as for some distance beyond its south-eastern limit, ridges more or less closely akin to true drumlins occur in considerable abundance. I am unable to assign a precise place to these in the scale of events of the glacial period. Attention was not specially directed to them till 1890, and the evidence respecting them is still in many respects incomplete.

Area characterized by drift-ridges.

The principal development of these drift-ridges is found in a belt of country to the south of Kamloops, extending in width from Cherry Bluff and Alkali creeks to the eastern edge of the map. From the latitude of Kamloops, this belt runs south-eastward, including the Stump Lake valley and the adjacent parts of the plateau on both sides, with the vicinity of Douglas Lake, and Chaperon Lake east of the edge of the map. To the northward of Kamloops no similar phenomena have been found, nor were they observed to the south of

the lakes last mentioned, although the country in that direction has not yet been very closely examined.

Character and elevation.

Within the area thus defined, the ridges have been found in great numbers between elevations of about 2500 and 3500 feet, although these heights are not stated as strictly limiting ones. The ridges take the form of long pencil-like accumulations of drift material, generally, but not always, sheltered behind and dependent on rocky projections. So far as observed, they point south-eastward or southward, in directions corresponding closely, in each case, with those indicated by the striation as that of the motion of the Cordilleran glacier. Superficially they consist of gravel and earthy material with small boulders, and although no satisfactory sections have been observed, they are at least in part composed of boulder-clay.

Localities where observed.

Drumlin-like ridges of the kind referred to, may be seen well developed in the wide valley of Alkali Creek, in the vicinity of the upper part of Peterson Creek and on the low plateau about Separation Lake. They are generally arranged in parallel series, and when viewed at right angles to their length simulate terraces, their crests often running nearly horizontally for a quarter or half a mile, but always eventually sloping down to the southward, and, where not manifestly dependent on rocky masses, declining in the same way to the northward. They are very well shown in the entire wide valley of which Stump Lake occupies the lowest part, occurring at all heights, from the lake-level (2450 feet) to the summit of a conspicuous hill which stands nearly isolated to the north-west of the lake, with an elevation of about 3600 feet. A sketch of the upper part of this hill is here given, and is of particular interest in showing two or three delicately impressed, but still quite distinct, horizontal terrace-lines, marked upon the surface of the drift material which has accumulated behind the rocky crag.

FIG. 11. SKETCH OF UPPER PART OF HILL NEAR STUMP LAKE.

Showing drift-ridge in lee of crag, marked with faint terraces.

North of the Upper Nicola Valley (above Nicola Lake) similar drift-ridges were observed at a height of about 3000 feet, with a south-easterly direction, as though the agent producing them had been diverted toward the less elevated country to the east of the Meander Hills. To the north of Douglas Lake, they were found at a nearly

corresponding height, running about S. 25° E., and to the west of Chaperon Lake to a height of about 3500 feet, with directions varying from S. 25° E. to south.

The only other part of the area of the Kamloops map-sheet in which such drift-ridges were noted, is on a portion of the plateau to the south of the lower part of Meadow Creek, and between that creek and Guichon Creek. Here the terrace numbered 12 in the list on page 278 B occurs. Rocky prominences standing above it, show long attached tails of drift pointing about S. 50° E., and the surface of the terrace itself is grooved by long hollows parallel in direction, evidently due to the same cause with the ridges, acting at the same time. The terrace mentioned here is at an elevation of 4400 feet, and as the ridges somewhat exceed this, they are the highest instances of the structure in question which have been found. Ridges contemporaneous with water action.

In this case it is pretty clear that the drumlin-like ridges and the terrace must either be contemporaneous, or that the terrace is the older. In that of the hill near Stump Lake, the terrace-markings must have been produced either at the same time with the drift tail or at a later date. In both the occurrence of water action in close relation to the ridges is apparent.

Respecting the physical features of the region first described, and that in which the main development of such drumlin-like ridges occurs, it may be explained that, apart from the narrow valley of the Fraser, it forms one of the principal southern outlets of the Interior Plateau of the province. From this it may be argued, that the circumstances attending the flow of the Cordilleran glacier along this wide depression, were those which gave rise to the ridges, in the manner ordinarily assumed for the formation of drumlins. But the Okanagan Valley, to the eastward, formed a second and at least equally important avenue for the escape of the glacier-ice from the plateau, and in this vicinity, although the circumstances appear to be equally favourable to their production, no similar well-marked ridges are found, and if they occur at all (of which I could not satisfy myself,) they are inconspicuous and insignificant. Physical features of region of drift ridges.

Drift-ridges of this character are therefore not a general normal result of glaciation in the region, but are due to some exceptional and relatively local cause, and the fact that they characterize chiefly a wide depressed area in the plateau country, through which the ice is known to have passed in their direction, is not in itself sufficient to show that they have been produced by the passage of such ice; for the same physical features would equally have given a similar direction to Such ridges exceptional.

any body of water seeking an outlet, and the existence of high terraces throughout the country, shows that it was deeply flooded during a part or parts of the glacial period.

Probable date of formation of ridges.

Although not in a position to arrive at any definite conclusions regarding the mode or date of origin of these drumlin-like forms, it may be useful to enumerate the main points which bear upon these questions, before leaving the subject.

They almost certainly antedate the White Silt formation, which is attributed to the latter part of the second epoch of glaciation. There is no reason to believe that either ice or water reached such high levels at or after that time, and, moreover, the White Silts themselves could scarcely have remained under the stress of circumstances such as to account for the production of the drift-ridges.

Their mode of origin.

This being admitted, it must be supposed that they originated either as a direct result of the passage over the country of the main Cordilleran glacier, or in consequence of circumstances immediately succeeding that event. They may thus have been formed :—(1) Beneath the mass of the great glacier in the manner usually attributed to drumlins. (2) Along the margin of the retreating ice either subaërially or below water. (3) By some exceptional and sudden movement of a great volume of water about the close of the time of maximum glaciation.

Against the first hypothesis is the exceptional character of the drift-ridges relatively to the whole area examined, and the freshness of their forms. Had their date been so early, they could scarcely have escaped much denudation and extensive burial during the submergence evidenced by the numerous high-level terraces. They must have been exposed successively at every level to the waves of the declining edge of the water, having already been subjected to the denuding action of the water flowing from the edge of the retreating glacier itself, whether on land or in a body of water.

Under the second hypothesis, it is easy to imagine that tunnel-like cavities may have been produced from time to time by the protrusion of the edge of the glacier over masses of rock, in which deposits resembling the drift-ridges might have been formed. But such cavities should be flaring outward, a form not followed by the deposits in question, and the effects of issuing waters, already alluded to, should be equally manifest in this case.

The third hypothesis, assumes that the ridges were produced partly by denudation and partly by accumulation, along the path of some

great and relatively sudden outflow of water. There is much evidence of denudation in the same region, afforded by the hollows of numerous small lakes. Such a local flood as that assumed by this theory, might occur either by the bursting of the icy borders of an englacial lake, like that already spoken of in connection with the origin of the higher terraces, or by a general outflow from the Interior Plateau consequent on some rather sudden movement in elevation of the land about the close of the first and greatest epoch of glaciation.

Moraines.

If the last-described hypothesis of the formation of the drift-ridges be correct, most of the moraines met with must be older than these. Some are certainly older than many at least of the terraces, others show evidence of contemporaneity with certain terraces, while a few appear to be relatively of quite recent date. As it is impossible to treat of the various phenomena of the glacial period strictly in their order of sequence, from doubt which exists as to this precise order, and from the overlapping in time of the various events, it has been decided to give a few notes on the moraines collectively in this place. Moraines of different classes.

Within the area of the Kamloops sheet, very numerous observations have been made on moraines. A considerable proportion of these are pretty evidently due to stages in the diminution of the Cordilleran glacier. In other cases, moraines appear to have been formed locally by the movements of subordinate masses of ice which becomes detached from the main glacier, and for a time remained, capping plateaux or other elevations; assuming a proper motion due in each case to the actual slopes of the country upon which they lay. Others, again, may with probability be assigned to the second though less severe maximum of glaciation, while in the mountains of the eastern margin of the Coast Ranges, a small increase of the present snowfall would reproduce the local glaciers to which some of the moraines there may be attributed. One of the more important features directly due to moraines, is the formation of many of the lakes with which the map is strewn. Moraine-dams hold in a large number of these lakes.

As the Cordilleran glacier gradually diminished, its front appears to have become very irregular in outline, and tongues or lobes seem to have occupied certain main depressions after the adjacent higher regions had often become free from ice. The moraines which occur in such valleys and which appear to have been produced in this way are always small, though often well marked. Their small size seems to show that Retreat of Cordilleran glacier.

the glacier retreated pretty rapidly, and though it may have occasionally re-advanced, did not long remain at any one place. The material composing these moraines, so far as it has been examined, resembles that of the boulder-clay, but is often more gravelly in composition and contains a larger number of rounded stones. No really typical moraines, composed of large angular or sub-angular blocks, such as those which occur along the eastern base of the Rocky Mountains in connection with the old local glaciers of that vicinity, are met with in this region, except possibly in the Coast Ranges.

Moraines due to this time.

Some miles beyond the southern edge of the Kamloops sheet. south of Nicola Lake and a few miles south of Lac à la Fourche, in an important valley which leads southwards toward the Similkameen, transverse moraines, evidently formed by ice pressing onward from the north, are found at an elevation of 3620 feet. In another valley which branches westward from Lac à la Fourche, moraines indicating a westward motion of ice occur at about 3830 feet, and it is evident that here, a subordinate tongue of the main lobe sought exit in that direction, at one stage in the retreat.

The next clear instances of this kind, little complicated with other phenomena, and due to a later stage in the withdrawal of the glacier-front, are met with near the lower part of the valley of the North Thompson, a few miles north from Kamloops. It is evident that an important lobe occupied the North Thompson valley, and that it spread at one time over the lower hilly tract named the Garde Lafferty. As it shrank back from this tract it left small moraines, one of which may be traced for a considerable distance across the undulating hilly country of the north-eastern part of the Garde Lafferty, as a well-defined low earthwork-like ridge. On the opposite side, this lobe, or a part of it, occupied the Inner Valley of the map, and the valley of the upper part of the north branch of Reservation Creek. Moraines were here observed at heights of 2400 and 2600 feet. A branch of the glacier seems also to have pushed eastward in the valley of Edwards Creek, and about the lake of the same name (a short distance beyond the east edge of the sheet), where moraines are numerous at a height of about 3200 feet.

Probable glacier lake.

The moraines in the valley of the north branch of Reservation Creek, are partly terraced by water action. Near Edwards Lake, terraces occur above the moraines, at a height of about 3500 feet, and it appears to be quite probable that a lobe from the Inner Valley here moved eastward, while one from the upper valley of Louis Creek (see p. 290B), pushed in an opposite direction, and that

the moraines and terraces are due to these and to the small glacier-lake which may for a time have been produced between them.

Moraines near Clinton.

Near the north-western part of the Kamloops sheet, the slopes of the Green Timber plateau, in the vicinity of Clinton, are covered by a confused mass of morainic material, rising nearly from the level of the wide valley in which Clinton is situated (3040 feet) for several hundred feet above it.

The occurrence of large quantities of basalt boulders, which have evidently been derived from the Green Timber plateau, in the part of this valley which runs toward Kelley Lake, doubtless indicates that a lobe of the northern ice for a time pushed in this direction, following the low ground.

Moraines and terraces on Marble Mountains.

The Green Timber plateau itself, was probably the last part of the Kamloops sheet which was connectedly covered by the diminishing mass of the Cordilleran Glacier. The occurrence of moraines in association with terraces, where this plateau is bounded to the westward by the southern part of the Marble Mountains, has already been referred to (p. 268 B). The moraines here are at a height of about 5500 feet above the sea-level. They may be regarded as lateral moraines, and their height seems to imply that at the date of these formations the surface of the glacier stood about 2000 feet above the lower part of the Green Timber plateau, to the north-eastward. Near the northern part of the same base of the Marble Mountains, moraines and terraces are again associated. These are alluded to on pp. 268 B, 278 B. The two principal levels of moraines noted here, are, near Big Bar Lake, 3730 feet, and again at a height of 4300 feet, and the connection of the moraines and terraces is believed to imply a couple of short re-advances of the glacier, by which the general progress of its recession has been interrupted.

Green Timber Plateau.

The general surface of the Green Timber plateau is also characterized by numerous moraine-ridges and by some ridges which may represent kames or eskers. A number of these have been noted in traversing the plateau, but no systematic survey of the whole has been made, though such a survey would probably bring out points of interest. These ridges are generally about fifty feet in height and seldom exceed one hundred feet. Between Big Bar Lake and the wagon-road to the south-east, they were noted particularly at heights of about 4150 and 3900 feet. They are associated with sandy terrace-flats, but are themselves often sharp and unaltered. Further east on the plateau, to the north of Fly Creek and between that stream and Green Lake (north of the edge of the map) similar moraines are again well developed, and the

old Brigade trail follows some of them for miles. These were found to be flattened off by water action at levels between 3790 and 3890 feet, but above the last-mentioned level, did not in this place show any distinct evidence of terracing.

In the foregoing paragraphs, it has been endeavoured to notice some of the moraines which more distinctly evidence the several positions of the retreating front of the Cordilleran glacier, but in so doing the connection of many of the moraines with contemporaneous or very shortly subsequent terracing has necessarily been alluded to. Other marked instances of this association of moraines with terraces may be noted as follows.

Association of moraines with terraces, Guichon Creek.

In the wide though rather high depression which, running from north to south, forms the valley of Guichon Creek, there is a remarkable association of moraines and terraces which must be assigned a proximately contemporaneous origin. Moraines are everywhere abundant on the upper part of Guichon Creek to the west of Toonkwa Lake, as well as to the east and south-east of that lake. In the last-named locality they tend to run north-and-south, and appear to be lateral moraines of a tongue or lobe. All these are at levels approximating to 4000 feet and show only occasionally some traces of water action. Further down, in the Guichon Creek valley to the north of Witches Brook, at a level of about 3500 feet, flat-topped moraine-ridges abound, both parallel to the sides of the valley and more or less directly transverse to it. Some of these have held in ponds, which have now for the most part been drained. On the west side of the valley, below Witches Brook, similar closely connected moraines and terraces occur at nearly the same height as before, and lateral moraines are very well marked in places on the opposite side of the valley. Again, on the west side of this valley and extending from a point about two miles below Mamit Lake southward for several miles, a remarkable display of rough, irregular moraine-ridges is found. Some of these are nearly transverse to the valley, others, particularly those nearest the present stream, in the bottom of the valley, run nearly parallel with it, but little general regularity in trend is apparent. The moraine-ridges are here full of granite blocks and boulders, and are so closely crowded together that they are often separated only by narrow V-shaped valleys. As noted elsewhere, (p. 279 B) terraces appear on the slopes of this part of the valley high above these moraines, which may be stated to occur at levels of 3300 to 3200 feet. Among the moraines, terraces formed of their material also appear, and in following the valley for a couple of miles further, the terraces become the more prominent feature, but still show, by the occasional pot-holes

which indent them, their superposition on moraine material. On the summit of the plateau, some miles to the west of this part of Guichon Creek, about the watershed between it and the main Nicola River, at heights of 4300 to 4400 feet, moraines and terraces are again found so closely associated as to suggest contemporaneity, but these belong to a different and probably earlier stage, and are possibly due to different conditions from those which have just been described.

Other instances of moraines and terraces.

Reverting to the moraines and terraces of the lower part of Guichon Creek, it is interesting to note (though in doing so reference must be made to a tract of country somewhat beyond the south edge of the map) how frequent the association of moraines and terraces is at a level approximately identical. In different places along the Coldwater Valley and following the Voght Valley to the sources of Otter River, extending thus about thirty-five miles southward from the locality particularly referred to as Guichon Creek, terraces were noted, in ascending, to be replaced by moraines at levels of 3310, 3220, 3230, 3260 and 3290 feet approximately. Taking into account the somewhat indeterminate character of the phenomenon and possible errors of observation in height, the facts seem to prove that water stood for some little time in this region at about the elevation indicated. A comparison of the circumstances here, with the generally higher levels of similar instances to the northward, suggests that an increasing depth of water followed the retreating edge of the Cordilleran glacier.*

Further examples of moraines.

The following are a few additional instances of places in which moraines were noted to have a considerable development, but in which they did not show any distinct relation to terraces. Some of these moraines may be due to ice moving from the higher parts of the region at dates subsequent to that of the main glaciation, while others are pretty certainly the result of the Cordilleran glacier itself in its waning stages.

Upper part of Moore Creek, to south-east of Trout Lake, numerous moraine-ridges, often parallel to the valley. Elevation about 3500 feet.

Meadow Creek valley—This contains numerous hillocks and transverse ridges, evidently representing moraines, but partly buried in horizontal deposits which have formed in ponds and marshes between them. Elevation about 4000 feet.

Murray Creek valley—Numerous moraine-ridges occur in the wide part of the valley, where a tributary stream enters, at an elevation of about 3790 feet. Terraces are found about fifty feet lower.

Cf. Trans. Ro Soc. Can., vol. VIII., sect. IV , p. 42.

Blue-earth Creek, a tributary of Hat Creek—In the lower part of the valley of this stream, transverse, gravelly, moraine-ridges occur at a level of about 4550 feet and somewhat lower. These appear to have been formed by an offshoot of the tongue of glacier-ice which at one time pushed southward along the upper valley of Hat Creek.

Medicine Creek, also a tributary of Hat Creek—Moraines occur in the lower part of this valley between about 3500 and 4000 feet. They have probably been produced in the same way with those last noted.

Vicinity of McLean Lake, between Ashcroft and Hat Creek—Very distinct moraine-ridges occur to the south of this lake, on the slopes of the hill, with easterly and westerly trends and deep narrow intervening valleys. Elevation about 4000 feet. Cattle Valley, running north from McLean Lake, is also in its southern part encumbered and often ridged across by moraines. All these moraines seem to have been formed by a tongue of ice pushing southward along the Cattle Valley.

Upper valley of Pavilion Creek, where it runs through the higher parts of the Pavilion Mountains—Much earthy drift in this part of the valley, apparently arranged in the form of moraines formed by an offshoot of ice pushing eastward.

Valley connecting Copper Creek with Criss Creek. Near the lakes in its northern part, at heights somewhat greater than 3000 feet, numerous small moraines, both longitudinal and transverse.

Moraines damming lakes.

Moraines directly concerned in the formation of lakes have not been enumerated in the foregoing pages. They do not of course differ in any essential respect from many of the others, but it has been thought best to note a few conspicuous instances of these together. Already several cases have been alluded to of ponds and lakelets held in by moraines but since emptied by the cutting down of their issuing streams. There are also almost innumerable cases of small ponds which lie in pot-holes in morainic country, or between moraine-ridges, which have not been considered to be worthy of separate note.

Instances.

Trout Lake, at the head of Meadow Creek, (4100 feet) is evidently held in by more or less degraded moraines. Fish Lake and Big Fish Lake on Greenstone Creek are similarly moraine-dammed at elevations of 4840 to 4100 feet. The moraines closing the first are more or less degraded by weathering or water action, but in the second case they are well preserved. These moraines are in part transverse to the valley but also in part parallel to it, and it is not possible to state whether they were produced by a tongue of the Cordilleran glacier or by local glaciers moving down from the adjacent plateaux. A small lake or

pond south of the middle part of Meadow Creek, not named on the map, is surrounded by moraine ridges. It here seems probable that a local glacier, descending from the eastward, may account for the moraines and for the preservation of the basin of this little lake. The lakes of the Highland Valley, with heights of about 3900 feet, are also moraine-dammed. As previously stated (p. 290 B) it appears that the ice forming these moraines came from the westward. The lakes in the northern part of Glen Hart valley, again lie between moraines which have been thrown down in the valley. Though not certain, it appeared to be probable that the ice forming these was a local tongue which for a time moved northward in the valley, towards Clinton. The small lakes in the southern part of this valley seem to be caused by fans which have locally interrupted the drainage. On the Green Timber plateau it has already been noted that lakes inclosed between moraines are common. The numerous lakes about Skoatl Point, are not evidently due to moraines, but appear rather to owe their existence to material of the character of boulder-clay, irregularly distributed over a previously uneven rocky floor.

The foregoing notes on moraines in general are not entirely satisfactory, because it is impossible to discuss individual cases at such length as to render manifest the bearing of the local topography on their existence or position. They may suffice, however, to show how commonly moraines are met with in the region covered by the Kamloops sheet, which may be taken as a specimen of much of the Interior Plateau of British Columbia. One fact is so striking as to deserve special mention, *i. e.* that no very large moraines have been found. The moraine-ridges seldom attain a height of one hundred feet above their bases and are often not fifty feet in height. It is further notable, that large boulders occur only exceptionally and locally in them, while much of their material appears essentially to resemble that of the boulder-clay, or, where it shows points of difference, these tend to evidence greater water action and more rounding of the contained stony material. All the circumstances seem to show that, though the ice occasionally ceased its retreat and even advanced again for a certain distance, the main movement in retreat was rather rapid, and most of the material thrown into the form of moraines when a halt occurred, or a temporary re-advance happened, was that which otherwise would have gone to form ordinary boulder-clay, or which had already been deposited in that form and was subsequently ploughed up.

General remarks on moraines.

None large.

It is further remarkable, that no moraines have been recognized in this area below a level of about 3000 feet above the sea, or in other

None at low levels.

words, that none of the lower and larger valleys are characterized by moraines. Various explanations may be suggested to account for this circumstance. It may be supposed, for instance, that such moraines as were produced in these lower valleys were subsequently destroyed during the period of denudation which appears to have followed the main glaciation. (See pp. 251 B, 271 B). It may again be suggested, that the considerable depth of subaqueous deposits which occurred in these lower valleys covered and masked the moraines, or such remnants as were left of them. It is believed that both these causes may have coöperated, but in the present state of our knowledge it is not deemed advisable to discuss the matter further.

Absent from vicinity of drift-ridges.

In conclusion, still another point may be remarked on. This is the relative, or possibly nearly complete, absence of recognizable moraines in the belt of country which is principally characterized by the occurrence of the peculiar drift-ridges which have been described in a preceding part of this portion of the report (p. 291 B). This statement applies principally to the notable valley which runs southward from Kamloops. As no satisfactory reason can be given to explain the original absence or paucity of moraines in this particular valley, it becomes reasonable to suggest that the special conditions which have produced the ridges have removed, or have so changed as to obscure, the older moraines. If it be admitted that the ridges resulted from a rush of flood-water at one particular stage of the glacial period, it is easily conceivable that such moraines as may have remained, resulting from the antecedent retreat of the Cordilleran glacier, may have lost their identity at this time and in the area so affected.

Glacial and Post-Glacial History of the Fraser and Thompson Valleys.

Valleys excavated during the Pliocene.

The excavation of the great valleys now occupied by the Fraser and Thompson rivers, is believed to have been accomplished wholly or almost wholly in the interval between the close of the Miocene Tertiary and the beginning of the glacial period. Many observed facts show the post-Miocene age of these valleys, but perhaps the most striking is the occurrence near Leon and Pavilion creeks and again about Big Bar Creek (the last-named situated a short distance beyond the edge of the Kamloops sheet) of horizontal basalts and sandstones referable to the Miocene, on both sides of the valley, but now cut through and fringing, far up, the edges of the plateau. Such excavation as may have occurred in these valleys during or after the glacial period, is, in fact, quite insignificant, compared to the pre-glacial erosion. It

is nevertheless a matter of some interest, particularly in its intimate connection with the problems offered by the occurrence of alluvial gold along these rivers.

As already noted, there can be little doubt that both these great valleys were throughout more or less deeply filled with boulder-clay, or analogous drift deposits, at the close of the first maximum of glaciation. This epoch is supposed to have been followed by a subsidence, during which, not only these valleys but much of the adjacent plateau country was deeply flooded, and this again is believed to have been succeeded by a reëlevation, that was either a forerunner of or coincided with the earlier stages of a second less severe and more local glaciation. The evidence relied on to show that the Fraser and Thompson valleys were during this time of elevation practically cleared of the boulder-clay deposits which had previously encumbered them, is referred to on page 271 B. On another page of this Report (p. 275 B) certain remarkable cones of dejection, composed chiefly of boulders and formed opposite the mouths of some streams which enter the Fraser and Thompson valleys, are described, and it is explained that these probably had their origin after the removal of the greater part of the boulder-clay, and during the earlier portion of a still later period of flooding of the valleys, before the close of which the White Silt formation was produced. Summary of glacial history.

It is difficult, in the presence of so many interlocking phenomena, to arrive at certainty as to the precise nature of the train of events, but that here sketched now appears to me to be the most probable one, and is referred to, with reserve, as a basis of arrangement for our ideas in respect to the later history of these great valleys.

In addition to the rough cones of dejection above alluded to, which were evidently formed only where there was an adequate supply of large boulders and occasional heavy local floods sufficient to transport these, many "fans" occur along these valleys opposite the mouths of streams. These are with probability assigned to the same period. In my Preliminary Report on the Southern Portion of the Interior of British Columbia (1877) I have named the accumulations here referred to "fans" (p. 10 B) following Drew* and no better descriptive name can probably be suggested for them. Nature of "fans."

Fans may be formed at the opening of a narrow valley upon a plain or wider valley either below water, as of a lake, or sub-aërially. In the former case, their slope from the mouth of the tributary valley, is generally low, How produced.

*Quart. Journ. Geol. Soc., vol. XXIX., p. 441.

their material is usually pretty well stratified, and under certain circumstances they become nearly flat-topped and pass into ordinary delta-plains. When formed sub-aërially, they are built up somewhat more irregularly, by the lateral deposition of débris by the stream itself, which continually changes its course to those parts of the fan which are lowest or least blocked by previously deposited matter. Fans are thus, in another direction, connected with cones of dejection, from which they differ essentially only in the greater fineness of their material. Fans of both kinds described above, are very common throughout the southern interior of British Columbia, but those to which particular attention is here drawn, in the Fraser and Thompson valleys, have evidently been produced at a time when these valleys were flooded. This is shown, first by the nature and arrangement of their materials, second by the fact that some of them have been able to spread completely across the valleys, which they could never have done while a large and rapid river occupied the valley.

Fans older than river-terraces.

The larger fans, of which there are many along the Fraser and Thompson valleys, have evidently been produced at a time previous to that of the formation of the river-terraces, which took place during the post-glacial period, for these terraces are cut out in the material with which the valleys were partially refilled after the removal of the boulder-clay and previous to and during the time of the White Silt formation. As instances of these older and more important fans, those of La-loo-wissin Creek, another stream two miles above this, and Cinquefoil Creek may be referred to. There is also a wide fan of this character at the mouth of Deadman River, to which the damming back of the water of Kamloops Lake is evidently largely due. Even the fan at the mouth of Hoey Creek, at Lillooet, though a small one, is cut away into terraces below and only its upper part remains intact.

Later additions to fans.

There are of course many smaller fans of later date than the terraces and of sub-aërial origin. These are often spread out upon the surfaces of some of the terraces, and doubtless the construction of fans has never entirely ceased since the beginning of the older ones and is still to some extent in progress. Many of the older fans have also, at later dates, received superficial additions sub-aërially. A good instance of this is seen at Eleven-mile Creek, two miles above Fountain Creek, where the stratified gravels and sands of an old and evidently sub-aqueous fan, are irregularly covered by a rough wash much resembling boulder-clay, but distinctly a deposit brought down by the stream. At a still later date, and in consequence of the lowering of the river-bed into which the stream discharges, the stream has cut a ravine through both

deposits. This subsequent trenching of the old fans is another feature common to most, or all of them.

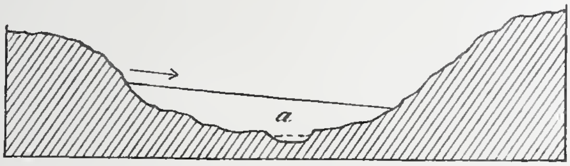


FIG. 12.—SECTIONAL DIAGRAM OF A FAN PROJECTED ACROSS THE WIDE RIVER VALLEY, DURING A PERIOD OF SUBMERGENCE.

a. Position of former river-bed.

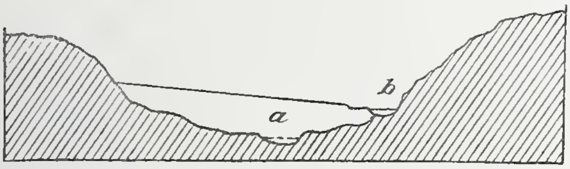


FIG. 13.—SECTIONAL DIAGRAM, SHOWING NEW CONDITIONS ON REËLEVATION.

a. Position of former river-bed.
b. New river-bed, forced against the rocky wall of the valley, and cutting terraces in the old fan.

Effect on course of river.

Where the larger old fans have been projected quite across the river-valley, the river, on resuming its course when the flooded state of the valley ceased, has selected the lowest point, and is therefore usually found to be pressed close to the side of the valley opposite to that on which the stream producing the fan enters. Here it has very often cut out part of its new bed in the rocks of the side of the valley, and in a few cases has cut a new channel largely in the rock and has thus formed a little cañon.

Connection with valley-filling generally.

These old fans are of course only special cases in the general process of the filling of the Fraser and Thompson valleys with drift materials, which ensued on their flooding and continued doubtless during the entire period of the formation of the White Silts. The materials with which the valleys were thus partially filled, consist of stratified gravels, sands and silts, evidencing no doubt, more or less current action, but such as may have effected a body of water with a large sectional area, and very different from any deposits of the present rivers. The silts are in certain places largely developed, and in some instances are very closely connected with, if they do not actually form a part of the fans. The principal localities in which the silty deposits are shown have already been referred to (p. 283 B).

Valleys at close of submergence.

During the subsidence of the waters in which the White Silts were laid down so widely in this part of the province, it is probable that a certain amount of erosion of a general character occurred, in these main valleys of outflow, before the water became actually concentrated into true river-channels. In any case, as a result of this period, the valleys were left, about the time that true river conditions resumed, deeply floored with drift deposits, in which during the post-glacial and modern period, with the country standing at or about its present elevation relatively to the sea, the Fraser and Thompson have reëxcavated their comparatively narrow actual channels, producing series of river-terraces as they cut down.

Depth of post-glacial excavation.

The depth of this post-glacial erosion varies considerably in different places, but can generally be approximately determined, by producing the light slopes of the remaining portions of the old floor, which can often be recognized, till these meet in the axis of the valley. Notes made in this manner, show that the Fraser Valley, near the mouth of Cinquefoil Creek and thence to Lillooet, was filled to a depth of 350 to 550 feet above the present water-level. From Lillooet to Pavilion Creek, the depth of filling appears to have averaged about 400 feet, while above Pavilion Creek it becomes rather deeper, and near the place at which the Fraser enters the Kamloops sheet, it appears to have been as much as 600 to 800 feet. On the Thompson River near Ashcroft, the surface of the drift deposits filling the valley stood at least 300 feet, and possibly as much as 500 feet, above the present river-level.

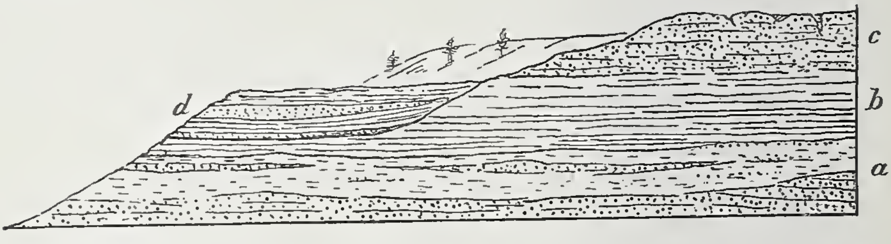


FIG. 14.—SECTION OF EAST SIDE OF THOMPSON RIVER, ABOVE THE BONAPARTE.

Illustrating the post-glacial reëxcavation of the Thompson Valley in later-glacial or interglacial deposits of the White Silt period. (See p. 325 B).

a. Stratified sands and gravels, often false-bedded, about 30 feet.
b. White Silts, in vertical bluffs, about 35 feet.
c. Stratified gravels, about 30 feet.
d. Re-deposited silts and gravels, filling post-glacial river-bed, 15 to 20 feet.

The lower line of the section is at the railway track, about 40 feet above the river. The bank below the railway appears to consist chiefly of stratified gravels, but is imperfectly exposed.

G. M. DAWSON.—Photo. Sept. 16, 1889.

FRASER RIVER, NEAR FOUNTAIN.
Showing Terraces and depth of post-Glacial Erosion.

Relation of modern rivers to 'bed-rock.'

The figures just given afford an approximate measure of the depth of the post-glacial erosion accomplished by the Fraser and Thompson, but this cutting-down was probably carried on pretty rapidly at first, and afterwards more slowly, as the river began to transgress on the rocky sides of the valley, or to reach its old rocky bed. The general result of an examination of the Fraser and Thompson rivers, so far as these are included in the map, from this latter point of view, seems to prove, that where the old rocky bed has been deepened at all, this has been to a very inconsiderable amount. Near the southern edge of the map and beyond it, the Fraser appears to have cut somewhat deeper than the bottom of the pre-glacial valley. Further up, above Lytton and between Cinquefoil Creek and Lillooet, it can scarcely have reached its old bed, for though in some places bordered by solid rock on both sides, the gravelly material of the terraces, often for considerable distances, descends to and apparently below the level of the water. Thus, where rock shows on both banks, the river must be supposed to have cut its new channel across projecting points. From Lillooet Bridge to Fountain Creek, however, the river is very generally bordered by rocks on both sides, in such a way as to show that it has probably accomplished some late erosion in the rock itself. It has certainly done so in the east-and-west portion of this part of its course, for some miles below Fountain Creek, where very steep rocky walls rise to a height of 100 to 300 feet above the water. The valley is here narrow and cañon-like and the new course of the river must coincide with the old, the former channel having been again cleared out between the same rocky walls.

Fraser north to Fountain.

Above Fountain.

For some distance above Fountain Creek, the river seems scarcely to have yet regained its old level, but above Pavilion Creek, the quantity and manner of appearing of the rock along its margins, leads to the belief that it has reached its old level or has even cut down somewhat lower than it. There are also in this part of the river, several little rocky cañons, which evidently show where the river has taken a new course in the wide trough-like valley and has cut across points of rock in so doing (p. 327 B).

Peculiar conditions near Fountain.

Reverting to the east-and-west part of the river below Fountain Creek, it may be added that the conditions met with there, appear to be such as to indicate a slight differential uplift of this part of its bed, which may have taken place along the axis of the ridge of Cretaceous rocks which crosses the river. It is, moreover, notable that no low river-flats of considerable size occur along the river for a considerable distance above this place, the new trench now occupied by the river, being cut through nearly the whole depth of the glacial filling. This may indi-

cate that it required a long time for the river to completely clear out the filling of the cañon-like portion below Fountain Creek. It cannot be supposed that any possible differential uplift was sufficient in amount to account for this particular feature. It certainly seems, however, that this cañon-like part of the river has been one of the latest to be fully excavated in pre-glacial times, and that a waterfall may have long existed here. That part of the Thompson above Lytton which lies in an east-and-west bearing, has a like, new, narrow and raw character, and appears to require a similar explanation. For the Thompson River generally, above the part just referred to, the evidence is not perfectly conclusive, but appears to point to the fact that it now flows little if at all below its pre-glacial level.

Thompson River.

It is certain, on the other hand, that the North Thompson, for at least twenty-five miles above Kamloops, and the South Thompson throughout its length, or to the point at which it issues from the Shuswap lakes, have not anywhere cut down to the level of their pre-glacial beds ; nor is the fall on these lengths of river, governed by the level of Kamloops Lake, at present sufficient to enable them to accomplish any appreciable amount of excavation.

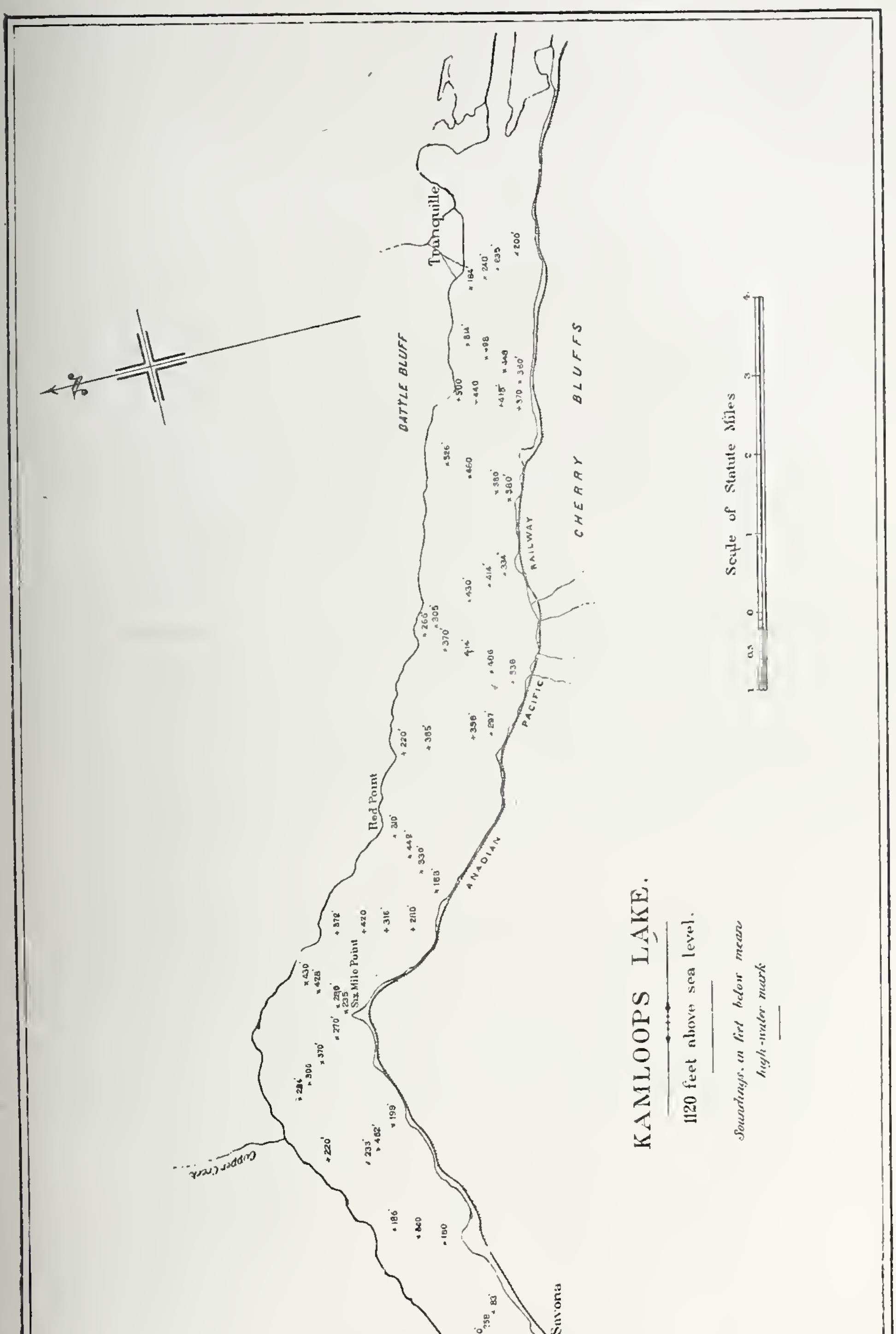
KAMLOOPS, NICOLA AND BONAPARTE LAKES.

Depth of Kamloops Lake.

A certain part of the valley of the Thompson is occupied by Kamloops Lake, eighteen miles in length, and if the history of the later Tertiary erosion is correctly given on page 318 B, the trough now occupied by the lake must have originated in the later Pliocene. Some soundings were made in this lake by myself in 1877, but in 1894 Mr. McEvoy carried out a number of soundings in all parts of its extent. The greatest depth found was 498 feet, between the eastern part of Battle and Cherry Bluffs, and the middle of the lake was found to be continuously greater than 400 feet in depth from this place to about opposite Six-mile Point, a length of nine miles. The part of the basin below 400 feet, is both deepest and widest toward the upper end of the lake. The lake is almost certainly in part a rock basin, for although the fan from Deadman River is partly accountable for the height of its water-surface, the character of the valley below, is such as to show that it could at no time have afforded free drainage to the deeper basin of the lake at the present relative levels.

Peculiar conditions of this lake.

The lake has therefore the general character of a fiord or fiord-lake, but differs completely from these in not being related in the usual way to a mountain range. It lies, it is true, in a hilly country, but one which is still essentially a part of the Interior Plateau, where the main



Drawn for photo-lithography by C.O. Senécal, C.E.

direction of glaciation is nearly transverse to it ; and although the ice of the glacial period may have had something to do with clearing the débris from its hollow (see p. 258 B) it does not appear possible, under any circumstances, to consider it as the result of glacial erosion.

Mode of formation doubtful.

The question of the mode of origin of this lake is one deserving further inquiry, and requiring comparison with fiord-lakes such as the Shuswap Lakes. I will here only add, that it seems most easily explicable on the hypothesis of local changes in elevation of the surface, by which this part of the Thompson Valley, after its excavation, became relatively depressed. Such a movement may have been accompanied by faulting, evidences of which at a date posterior to the Miocene are found near both ends of the lake. It will be noted, however, that this supposition does not accord with the permanence of relative level of the surface assumed in connection with the origin of the early Pliocene valleys. The matter is still an open question.

Nicola Lake.

A part of Nicola Lake is also included by the map. A few soundings made in this lake, near the south line of the map, showed the bottom to be almost perfectly flat, with a depth of 130 to 150 feet. In Bonaparte Lake, no soundings were made, but the shelving character of its shores indicate that it is probably not very deep. In connection with the theory of a relative depression of a portion of the surface of the Interior Plateau, it is worth noting that the three large lakes of this district lie nearly in line, north-and-south, though each of them is transverse to this general direction.

Bonaparte Lake.

MINERALS OF ECONOMIC VALUE.

Object of this chapter.

In the following pages, the conclusions respecting the distribution and mode of occurrence of placer gold which result from the geological study of the region here reported upon, are given in summarized form. This is followed by notes on the various deposits of ores and other useful minerals, including details not given in the foregoing sections of the report, and referring, wherever necessary, to these pages.

AURIFEROUS PLACER DEPOSITS OF DIFFERENT PERIODS.

Investigation for sources of gold.

One of the more important questions of an economic kind connected with the particular region here described, but one which is common also to the greater part of British Columbia, is that of the sources of the gold contained in the placer deposits of the rivers and streams. In investigating this, it is desirable not only that quartz-veins traversing the older rocks should be examined, but also, from the generally close

associations of gold with pyrites, that any considerable masses of rock which have become charged with pyrites should be tested, and that attention should further be given to the conglomerates found to occur in the several formations, representing as these do, the river wash or shore work of former periods of denudation and concentration. With this object in view, specimens were collected from a number of localities, during the progress of the geological work, and of these, those which appeared to be the more important, by reason of their mass or because of other circumstances, have been subjected to assay in the laboratory of the Survey. Assays made.

In most cases, specimens of this kind naturally prove to contain nothing, but where they are found to hold traces of gold, this may be taken as an incentive to further examination of the deposits. The following is a list of specimens examined of pyritized rocks, very often in a decomposed and rusty state, which yielded traces of gold:— Pyritous rocks containing gold.

1. Decomposed syenitic rock with pyrites. Near the little lake shown on the map to the south of Edwards Creek.

2. Decomposed rocks (quartzites?) of the Câche Creek formation. Red Hill, 4½ miles south of Cornwall Creek and ¼ mile east of the wagon-road.

3. Rusty quartzite, 1½ miles west of northern part of Stump Lake.

4. Ferruginous deposit with basalt. Clinton Creek, above the town.

5. Reddish quartzite, 7½ miles north of Clinton, at east base of Marble Mountains.

6. Rusty, shattered and altered rock. Near north edge of Granite. Great Rock-slide, Thompson River. Gold trace. Silver 0·175 oz. to the ton.

7. A considerably metamorphosed greenish-gray rock, apparently clastic, with grains of iron- and copper-pyrites. In-kai-kuh' Creek, Thompson River. A mile east of the railway.

8. Shattered and dolomitized rock. Near the wagon-road between Kamloops Ferry and Tranquille.

9. Decomposed and rusty diabase rock. East side of Nicola Lake, half a mile from the head of the lake.

10. Shattered, rusty Cretaceous rocks, near mouth of Texas Creek, Fraser River.

The following specimens afforded no trace of gold:— Pyritous rocks without gold.

11. Decomposed schists, 4½ miles south of Cornwall Creek and 1¼ mile west of the wagon-road. Trace of silver.

12. Rusty decomposed volcanic rock. Cairn Mountain, Clear Mountain Range.

13. Rusty decomposed rock. Hills south of Nicola Lake, 1½ mile east of outlet.

14. Decomposed and rusty schists. East side Napier Lake.

15. Rusty Cretaceous rocks, forming wide zones in the formation. West side of Fraser River, three miles above Fountain Creek.

16. Shattered and pyritized rock of the Câche Creek formation. Wagon-road 2½ miles north of Hat Creek.

17. Quartz and wad. Clinton Creek, above the town.

18. Red and purple quartz or quartzite. In drift at Clinton.

19. Silicified and rusty quartzite. Cretaceous. One mile east of Fountain Creek, near the wagon-road.

20. Rusty, shattered, and altered rock showing some copper carbonates. Near north edge of granite, Great Rock-slide, Thompson River.

Referring to the foregoing assays, the following notes may be added respecting a few of the localities represented which appear to me to warrant further investigation as possible sources of gold in paying quantities.

Syenite with gold.

No. 1. The syenitic rock met with near Edwards Creek, is peculiar in its character and appearance and is evidently a true intrusive mass (see p. 246 B). It contains a considerable proportion of pyrites, which is evidently auriferous, and it is quite possible that some portion of this mass may prove to contain a workable quantity of gold, constituting a deposit of low grade, but obtainable in large quantity at an almost nominal cost. Gold was not only found in this rock on assay, but also observed in a thin slice, microscopically examined. The syenite intrusion extends for a considerable distance in a south-eastward direction, beyond the limits of the Kamloops sheet.*

Crushed pyritous rocks.

No. 2. The shattered and reddened rocks of some parts of the Câche Creek formation, in the vicinity of the Thompson and Bonaparte rivers, constitute a striking feature (see p. 80 B). The reddened rocks are largely either quartzites or rocks of other composition more or less completely silicified. At the surface they appear as red or yellow crumbling slopes and low hills, but in depth it is found that they are charged with large quantities of disseminated iron pyrites. The quantity of rocks of this character is practically unlimited, and the assay quoted

* Attention has very recently been drawn to the auriferous granites of the Timbarra gold-field, New South Wales, rendering the above-mentioned occurrence all the more interesting. Records Geol. Surv. N. S. W. vol. IV., part IV., p. 154.

shows that they contain some gold, at least in certain parts of their extent. It therefore appears to be well worth while to thoroughly sample the exposures of rocks of this class, wherever they present themselves, for in event of the recognition of any zone in which a payable quantity of gold may occur, an enormous quantity of lower-grade milling ore might be obtained from them and worked with ease. No. 6 may be classed under the same head, as representing an extension of the altered Câche Creek rocks above alluded to.

Rich 'float' near Clinton.

The discovery of several loose specimens of rock containing richly auriferous hæmatite, in the gravel deposits near Clinton, has been noticed in a previous report.* Inquiries made on the spot, show that such specimens, consisting of jaspery hæmatite with quartz, have been found in three separate places near the west end of the town of Clinton, and one of these, subjected to assay, is reported as yielding gold to the value of $300 to the ton. The source from which these fragments have been derived has not yet been ascertained, but the gravelly mounds in or near which they occur, are evidently of the character of moraines, due either to the period of recession of the main Cordilleran glacier, or to that of local glaciers of somewhat later date. In the first cases, the origin of the loose material should be sought for to the north-north-westward, somewhere along the eastern watershed of the Marble Mountains ; in the second, probably more to the north-westward, but in either case in some part of the Marble Mountain range or in its vicinity. In the same gravelly deposits, specimens of red quartzites or silicified argillites occur. These are not very abundant, but their occurrence is rather unusual in this region. Thus, when in travelling northward from Clinton specimens of similar red rocks were found from time to time, till rocks of the same character were found in place at the east base of the Marble Mountains between Clinton Creek and Sandy Creek, it appeared to be probable that the source of the associates of the auriferous specimens, at least, had been discovered. No. 5 of the foregoing list, represents the rock found at this place and it proved to contain, as will be observed, traces of gold. It would thus appear, that the eastern edge and the eastward slopes of the Marble Mountains, well deserve to be closely examined and searched for the possible place of origin of the richly gold-bearing specimens first alluded to, the clue being in the first instance afforded by the general study of the character and direction of the glaciation by which the country has been affected.

Its probable origin.

Conglomerates carrying gold.

Passing now to the second class of possibly auriferous materials above alluded to, the conglomerates of various ages, it may be

* Annual Report, Geol. Surv. Can., vol. III. (N.S.) pp. 54 R, 144 R.

explained, in the first place, that to test these thoroughly, a considerable mass of rock in each case should be pulverised and sampled in order to obtain a specimen entirely suited for assay. This arises from the fact that such conglomerates may be expected to contain visible grains or pellets of gold, like those met with in the more recent placers, that these may be but sparingly distributed and that large masses of intervening rock may be practically barren. The means were not at hand to subject the conglomerates met with to treatment of this kind, and the specimens actually assayed have been merely hand specimens, so that the investigation of the possibly auriferous character of the conglomerates must be regarded as being as yet very incomplete. The assays actually made have, moreover, been confined to a small number of conglomerates, all of Tertiary age but two, which are Cretaceous. The following is a list of such assays :

Specimens examined.

1. Rusty Cretaceous conglomerate. Cliff to the east of the Fraser opposite Lillooet Bridge (p. 152 B). No gold.

2. Rusty cretaceous conglomerate. East side of mouth of Botanie Creek (p. 153 B). No gold.

3. Cherty conglomerate (Oligocene). Near Copper Creek (p. 162 B). Traces of gold.

4. Cherty conglomerates (Oligocene) one mile south of Lac à la Fourche (p. 69 B). Traces of gold. (This locality is situated some miles beyond the edge of the present map—about 12 miles south of Nicola Lake, in the valley of McDonald River or Quilchenna Creek.)

5. Rough basal conglomerate (Oligocene). Plateau 2 miles south of Thompson, opposite mouth of Deadman. Traces of gold (p. 160 B).

6. Outlier of dolomitic conglomerate (Oligocene). Garde Lafferty, north of Kamloops (p. 163 B). No gold.

7. Cherty conglomerate (Oligocene). Hat Creek (p. 212 B). No gold.

8. Cherty conglomerate (Oligocene). Near McLean Lake (p. 213 B). No gold.

Gold in Oligocene conglomerates.

It thus appears, that in three localities of the occurrence of the peculiar cherty conglomerates of the lower Tertiary, traces of gold have been found. In three other Tertiary conglomerate specimens, and in the two only specimens of Cretaceous conglomerates examined, no gold has been found. It may, I think, be assumed that wherever traces of gold can be detected in a hand specimen of a conglomerate, it is worth while to further examine the deposit, to investigate particularly its lower layer upon the old bed-rock if this can be reached, to test in succession each of the superposed beds which shows points of difference, and to seek for any layers in which notable

quantities of pyrites, magnetite or other heavy minerals have accumulated. Magnetite is perhaps the most constant associate of gold in placer deposits of all kinds, and a ready mode of ascertaining its presence in conglomerates is found in pulverising these and applying the magnet to the powder.

Composition of various conglomerates.

It is not necessary to enter at greater length into this general subject. Some remarks upon it will be found in my previously published Mineral Wealth of British Columbia.* It need here only be added that the coincidence of the belt of Cretaceous rocks, holding much conglomerate, with the line of the Fraser River, which in its recent placers has proved to be richly auriferous, suggests the possibility that the gold found may in part have been derived secondarily from these conglomerates. The proximity of the conglomerates to the schistose and slaty rocks of the same region, from veins in which most of the gold has probably been originally derived, in itself affords some reason to assume the existence of gold in these conglomerates. On the other hand, the great abundance of diabase and diabase-like fragments in the conglomerates, may show that the distinctively gold-bearing rocks were not at the time supplying much material towards the formation of the conglomerates. The composition of the early Tertiary (Oligocene) conglomerates is in general very different. Their material has been very largely derived from the outcrops of the lower parts of the Câche Creek rocks, to the east of the main limestone belt. These rocks are traversed by very numerous, though generally small, quartz-veins and the occurrence of more or less gold in their débris, wherever this has been properly concentrated by natural agencies, may be looked for with considerable confidence. It appears to be probable, for example, that gold found in Criss Creek has been derived from these conglomerates, which are cut through by it.

None of the older conglomerates of the Câche Creek formation, found in limited beds on and near the North Thompson, have been examined for gold.

Experience elsewhere.

Since the above notes on the possible occurrence of workable auriferous conglomerates in British Columbia were written, additional encouragement to investigation in this direction has been given by development elsewhere. The continued and vast importance of beds of this character in the Transvaal may be alluded to. In California, Mr. R. L. Dunn has lately described Cretaceous conglomerates which have proved to contain payable gold and have been the source of local placers ;† and in Central Otago, New Zealand, Mr. A. McKay tabu-

* Annual Report, Geol. Surv. Can. vol. III. (N.S.) p. 47R, *et seq.*

† California State Mining Bureau, 12th Report (1894), p. 459.

lates seven or eight "auriferous wash-drifts" of which four are of Cretaceous or Tertiary age.*

Different systems of Tertiary rivers.

The older Tertiary or Oligocene conglomerates above referred to, represent remaining portions of the products of the earliest great period of Tertiary denudation. It is elsewhere explained (p. 69 B) that these beds subsequently suffered some disturbance, at least locally, and that during a succeeding period of considerable duration, denudation again progressed actively. A new or considerably modified system of drainage must at this time have been produced. This period of waste was brought to a close by the great volcanic eruptions of the Miocene, and these must undoubtedly have covered up many stream- and river-beds of the time. The quantity of volcanic products due to this period in the area of the present map, must have been such as to entirely obliterate the previously existing drainage system, the evidence being that all, or nearly all, the valleys of the present rivers and streams, have since been excavated along new lines, largely determined in the first instance by the distribution and local mass of the volcanic accumulations which gave form to the surface.†

Pre-Miocene erosion.

Whenever these later erosions, whether confined to the valleys of streams or extending more widely from these, have cut down to the old pre-Miocene surface, any gold which may have been contained in the old stream-courses of this surface has of course been redistributed and has gone toward the enrichment of the modern gravels. But where the volcanic rocks remain, the old drainage-channels probably still exist beneath them intact. In districts based upon the older rocks referred to the Câche Creek formation, these channels may reasonably be expected to contain more or less gold. This is, however, less probable, where the underlying rocks are those of the Nicola formation.

Drainage system buried.

Very few instances are found in the Kamloops sheet, in which basaltic or other volcanic rocks still actually floor valleys antedating the Miocene volcanic period. The valley between the Marble Mountains and Edge Hills is, however, probably a case of this kind, and it is possible that parts of an old channel may exist here beneath the basalts. In most cases, there is no existing indication of the position of such old drainage-channels, and as a matter of fact none such had yet been exploited. It is quite clear, however, that large

* Geol. Reports on Older Auriferous Drifts of Central Otago (1894), pp. 33, 34.

† On the general subject of the physical features at different periods and the epochs of denudation and deposition, reference may be made to a paper by the writer on the Later Physiographical Geology of the Rocky Mountain Region in Canada. Trans. Royal Soc. Can., vol. VIII., sect. IV., 1890.

relatively-level tracts now covered by basaltic or other volcanic rocks, such as those of the Green Timber, Bonaparte, and Arrowstone Hills plateaux, must have been provided with well developed systems of drainage before the time at which they became covered with volcanic products, and it can scarcely be doubted that some at least of these will yet be discovered, and followed up if they should be found to yield gold in payable quantity.

Possible robbing of early placers.

Some of the occurrences of gold in the gravels of existing rivers and streams, very possibly depend on the robbing by these rivers of pre-Miocene placers. Thus, the local occurrence of coarse gold on the Thompson, near Nicoamen, is difficult of explanation except on this hypothesis. The Tertiary rocks, including sedimentary materials below, and consisting entirely of volcanic rocks above, here overlap the steeply-sloping edge of the granitic rocks of the Scarped Mountains. It is almost certain that this margin of the old rock-surface continues to slope down beneath the Tertiary strata below the present river-level, and that if followed, it would terminate in the bottom of a pre-Miocene valley, now covered; though whether this may have drained to the northward or to the southward along the base of the granitic hills cannot be determined. The border of the Tertiary rocks in contact with the granitic materials, is considerably broken up and distributed, so that it may easily have happened that portions of the old valley-deposits have been brought up and have yielded their contained gold to the denudation of the present river. The explanation suggested in this case is of course merely a conjectural one, but it is instanced as an example of the manner in which a study of the geological conditions and history may assist in determining the most probable places in which to seek for the older auriferous deposits. (See p. 107 B.)

Nicoamen.

Old gravels free from glacial interruption.

It is to be noted, that in the case of any auriferous gravels beneath the volcanic rocks of the Tertiary, these will have been exempt from the scouring and transporting action of ice during the glacial period, which has undoubtedly resulted, in the case of the more modern deposits, in obscuring and complicating the question of the origin of the gold, as well as in breaking the continuity of the deposits, and in some instances, probably, in dispersing concentrations of gold naturally brought about before that period.

Early Pliocene valleys.

Another and still later system of old valleys occurs in the district, to which a few words of description may be given, for though no attempt is made in the present Report to repeat in detail the study of the

successive physiographical events of the Tertiary, on which the paper last referred to may be consulted, it is desirable from an economic point of view to point out the various directions in which search for the older gold placers may be made. This system of valleys is referred to the Pliocene, or latest Tertiary period, the close of which is marked by the onset of the conditions of the glacial period.*

When the great period of accumulation of Miocene volcanic materials upon the surface of the Interior Plateau came to an end, there is reason to believe that the country stood at a level considerably lower than the present, relatively to the sea. The streams of the new drainage system which outlined itself, appear to have possessed rather low gradients, but their action was long continued, and resulted in considerable denudation. The streams themselves, in many cases appear to have excavated nearly to the maximum depth which the height of the country admitted, and to have produced somewhat wide, but usually not very deep, trough-like valleys, which may still be recognized in many places and which are generally still occupied by existing streams, though in some cases now interrupted or abandoned in consequence of later changes.

Later Pliocene erosion.

After this action had been in progress for a long interval, a very considerable and general elevation of this part of the Cordilleran region must have occurred, by which the gradients and powers of erosion of the rivers became greatly increased. A comparison of the average levels of the old valleys with that of the present levels of the Fraser and Thompson in their vicinity, leads to the belief that this elevation must have amounted to about 3200 feet.

Great changes effected at this time.

The results of this great increase in the elevation of the land were important. Such rivers as the Fraser and Thompson, fed by the perennial snows of extensive mountainous districts about their sources, were then enabled, by the increased gradients given to them, tc cut down so rapidly as compared to other streams less copiously supplied, that they become the main drainage-channels of the country. From the low levels thus soon achieved by these main streams, their lateral branches cut back rapidly in some cases trenching the bottoms of the valleys of the earlier Pliocene erosions with deep newly cut ravines, in others crossing them and diverting their waters to new and more direct courses. Thus great changes were worked on the drainage system of the region as a whole, and the system of water-

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*_Ibid._ p. 16, _et seq._

courses as it now exists, was, in respect to all its main features, completed.*

Heights of early Pliocene valleys.

In the following list, the best marked examples of the early Pliocene valleys of low gradient met with in the Kamloops sheet, are enumerated. The elevations set opposite the names of the several streams, are those ascertained for the lower remaining parts of the old valleys, below which, in each case, the existing stream falls into a steep gorge-like valley, which it descends to one or other of the main river-valleys, or to some deeply cut tributary of these :

	Feet.
Meadow Creek (upper valley)	3,350
Pukaist-Creek (")	3,750
Witches Brook (")	3,650
Three-lake Valley (south part)	2,750
Kelley Creek (lower part) and Junction Valley	3,300
Câche Creek (upper valley)	2,650
La-loo-wissin Creek(upper valley)	3,450
Pavilion Creek	2,300

Possibly auriferous.

A careful inspection of the map, with its contour-lines and the elevations otherwise noted upon it, will afford more information on this subject than any further general description could give. From what has already been stated, it will be evident that wherever the early Pliocene valleys have been excavated on or near to areas of the older rocks, and particularly those of the Câche Creek formation, placer deposits of gold referable to the time of erosion of these valleys may be looked for. It must be borne it mind, however, that these valleys lay open to the work of the ice of the glacial period, and that it is probably in the main, if not alone, in such of them as lie transverse to the general direction of motion of this ice, that placer deposits may be expected still to remain intact. Where the direction of the old and wide valley nearly coincided with that of the motion of the Cordilleran glacier, it is probable that in most cases the original deposits may have been swept out to the bottom by this agent.

* It may be appropriate to note here, that much remains to be ascertained in detail, respecting the progress and various arrests of the post-Miocene period of erosion. Many interesting details are yet to be explained. A subsidiary feature of this kind, and one of some importance, occurs in the vicinity of Kamloops lake, where the rocky bottoms of wide trough-like valleys, into which the modern streams of the lower parts of the Tranquille and of Copper Creek have cut, have an elevation of about 800 feet above the present lake (1900 to 2000 feet above sea-level.) The terrace-like main bottom-level of the Thompson valley near Eight-mile Creek, is nearly the same, and the evidence appears to show an epoch of stability of some duration, between that of the low elevation of the early Pliocene and that of the high elevation of the later Pliocene. The notably low and wide valley of the lower Deadman, unless it may be assumed to be due to faulting at the time mentioned in pages 175 B, 310 B, likewise awaits explanation, being otherwise apparently inconsistent with the course traced out for the formation of the Old Câche Creek valley (p. 320 B.)

Instances.

By reason of the character of the rocks through which they are in part excavated, and because of their direction relatively to that of the general glaciation, the Kelley Creek and Junction Valley, together with the higher or early Pliocene valleys of Pavilion Creek and Câche Creek, appear to be, amongst those above enumerated, the most likely to contain old gold placers beneath their more recent filling of drift deposits. The upper valley of Câche Creek has been particularly instanced in the paper already referred to, (p. 19 *et seq.*) and is there shown on a special map. It may be traced upon the Kamloops sheet, following the Pass Valley eastward, crossing the Deadman River, continuing by the Red Lakes to the Tranquille River, nearly following this river for some miles, then crossing the Middle Fork and Watching Creek above their mouths and reaching the Garde Lafferty by Pass Lake. In this instance, the water which originally flowed through the old valley appears to have been intercepted at several points by Eight-mile Creek, Deadman River and the Tranquille River, all discharging at right angles toward the great later valley of the Thompson. The only portion of this particular early Pliocene valley which was excavated in possibly gold-bearing rocks, is its eastern part, toward the Garde Lafferty. This part may not only have obtained some gold directly from veins in the schistose argillites of that vicinity, but is also known to have been engaged in carrying the denuded material of the older Tertiary conglomerates, of which remnants are still found there. It would thus appear, that the valley in which Pass Lake lies, may still contain some of the old auriferous gravels of the early Pliocene, in the lower deposits filling it, and that it is very possibly to the subsequent robbing of such old placers, that the auriferous character of the lower part of the present Tranquille Valley is due.

Old Câche Creek.

Pass Lake Valley.

Three-lake Valley.

The Three-lake Valley, enumerated in the list just given, appears to be a special case. There is some reason to suppose that the Fraser River, before it cut through the Cretaceous ridge near Fountain, flowed for a time through this valley. That the valley is deeply filled with drift deposits, is shown by the disappearance of streams which flow into it and the subsequent reappearance of their waters in springs in its southern part. The trend of this valley is, however, such that the ice of the Cordilleran glacier must have flowed almost directly along it, and this circumstance renders it doubtful to what extent any auriferous gravels which may be supposed to have been deposited in it, still remain there undisturbed, beneath the modern cover.

Events of glacial period affecting gold deposits.

In outlining the history of the recent denudation of the country, we have now arrived at a time in which the deep valleys of the Fraser and its main tributary the Thompson were formed. The next event was the

spread of the ice of the Cordilleran glacier over the whole region. The conditions thus brought about and the changes produced, it has been endeavoured, as far as possible, to follow in foregoing pages. The resulting effects on the occurrence and distribution of gold in the Fraser and Thompson valleys, may now be alluded to, in the endeavour to follow the story of their gold accumulations, in the light of the geological investigation of the region. The succeeding notes on this subject, must be read in connection with what has already been stated respecting the glacial and post-glacial history of these great valleys.

Conditions affecting the Occurrence and Distribution of Gold Placers in the Valleys of the Fraser and Thompson.

Original conditions in Fraser and Thompson valleys.

The concentration of gold in certain layers of limited thickness, such as to form rich auriferous placer deposits, has without doubt occurred only during the periods of erosion or cutting out of the valleys. During the long period of erosion in which the great trough-like valleys of the Fraser and Thompson were originally produced, in the later part of the Tertiary era, analogy with other well-known cases leads us to believe that rich gold-bearing deposits must have been formed along the rivers. Where the river itself cut its way through auriferous rocks, as was doubtless the case along many parts of the Fraser and some parts at least of the Thompson, or where rapid tributaries which were engaged in excavating such rocks entered the main stream, deposits of 'coarse' gold must have been produced. The rapid current which undoubtedly characterized these rivers at this time, would naturally lead to the trailing of the finer particles of gold along their entire lengths. Had the miner been on hand to exploit the prehistoric placers, as they existed at the close of this long period of denudation, he would in all probability have found them to be richer and more regular in character than any of those discovered by the pioneers of 1858 and 1859. In Cariboo, it is believed that the richest old channels, such as those of Williams and Lightning creeks, met with beneath the boulder-clay, actually date from this period. A thick rib of the Cordilleran glacier must, however, have followed the north-and-south valley of the Fraser, and it is possible that, as a result, the pre-glacial river-gravels were either entirely removed or much displaced and disturbed. It is not known that any pre-glacial placers have been found or worked on either the Fraser or Thompson. What has already been said as to the reaches of the Fraser in which its post-glacial channel is still higher than the level of the old pre-glacial rock-floor (p. 307B), shows

Pre-glacial channels not yet tested.

it is to be possible, that if spared by the great glacier, portions of this old channel may yet remain, though below the water-level, and therefore very difficult of access.

Gold disseminated in boulder-clay.

Much of the material which must have filled the old channel, together with débris from a distance, may doubtless have been incorporated in the boulder-clay, but the mass of this deposit is so thoroughly commingled, that whatever gold may occur in it must now be sparingly and irregularly disseminated. It is likely that the next important concentration of gold, occurred during the later time at which the boulder-clay itself became subject to denudation, and some placer deposits may yet be discovered in the gravels due to this period of waste, such as those found overlying remnants of boulder-clay near Ashcroft (p. 273 B). In the succeeding period, during which the large valleys were again being filled with detritus while they were in a flooded state, a certain amount of gold was no doubt also brought into them, whether from the transport of material from the boulder-clays of the adjacent slopes, or that derived directly from the waste of rocks then in progress. Such gold must, however, have been irregularly distributed through the entire mass of the deposits which went toward filling the large valleys, and only in certain places, where streams brought their material from richly auriferous localities, can it be supposed that these deposits as a whole—whether horizontally arranged or in the form of fans—may contain enough gold to enable them to be worked at a profit.

Later glacial concentration and filling of valleys.

Post-glacial concentration.

When, however, the post-glacial erosion of the Fraser and Thompson valleys began, the conditions were changed. The rivers in gradually cutting down through the drift-filling, swung from side to side of the often wide valleys, so that the surface of every river-terrace may be considered as more or less exactly representing part of the bed of the river at a certain stage in its descent.

Gold deposited in various old channels

In each of these old river-beds, a certain proportion of the gold, which had been disseminated in the material cut away and removed by water, became concentrated; and when the river cut down to a still lower stage, this was left in the gravelly and bouldery wash of the old bed. In most cases, however, these beds were in turn cut away by the river when operating at a still lower stage, and thus instead of continuous river-channels at various elevations, we find only the bouldery and gravelly materials of parts of old river-beds, capping more or less irregular and limited terrace-flats. It will further be obvious, that whenever a lower and newer channel of the river, in the course of this

period of denudation, either coincided with or cut across any portion of an older bed, this would be robbed of its accumulated gold and the later river-bed would be correspondingly enriched locally. This, with the original differences in richness which must have existed as between different places, goes far to explain the varying character of the placers met with on the several terraces, or benches along the valley and in the bars of the modern river. It will also be apparent that, other things being equal, the lowest and latest river-channel should be the richest, for though in the progress of those changes a considerable part of the gold must have become so highly comminuted as to be carried away by the stream and altogether lost, and though other portions of it were left on the rearranged surfaces of the river-terraces, a considerable proportion of the whole amount originally contained in the drift-filling of the valley, must in the end have been concentrated in the bed of the present river.

Latest channels richest.

The foregoing considerations may appear to be of a somewhat theoretical character, but most of them scarcely admit of doubt, and the conclusions arrived at agree with the facts as observed by the miners. It is thus of importance to clearly picture to the mind the way in which the placer deposits were formed, in order to recognize the places and conditions under which they should be sought for. Miners who have worked upon the 'benches' of the Fraser and the Thompson, affirm that the payable gold (which except in certain limited localities is usually fine) is invariably, or almost invariably, found in a yellow layer a few inches to a foot or more in thickness, not far below the surface of each bench, and very generally in association with a coarse bouldery or gravelly wash. The appearance of nearly all the old claims, most of the richest of which were worked out many years ago, tallies with these statements and with the explanation of them above given. It is not merely that the mining ceased to be profitable when a certain depth of cover was exceeded, for in many cases a good head of water was available, and if recurrent pay-streaks had existed throughout the thickness of the benches, these could in such instances easily have been sluiced away and the whole of the gold obtained. The general mass of the material composing the terraces or benches along these rivers has not been proved to be payable when worked by ordinary rough methods. When such work is entered into, the miner is called upon to concentrate disseminated deposits, like those which have elsewhere been concentrated naturally for him by the river itself.

Actual mode of occurrence of gold.

Confined to certain layers.

Deposits suited for hydraulic work.

The question is often asked—In a valley which has proved to be so richly auriferous as that of the Fraser, may not the terraces everywhere be profitably worked by the hydraulic method on the large scale? So far as a limited experience of the method goes, this does not seem to be the case, but it may be considered as demonstrated that some portions at least of the great mass of terraced deposits which still remain in the valley, are susceptible of profitable treatment by this method. One or two trials will not test this important matter completely, and in further endeavour towards its solution, it is necessary to bear in mind the general principles governing the formation of the placer deposits as a whole. The most favourable places for such further trials, are doubtless those in which rapid tributaries from known auriferous districts have piled their débris into the old valley of the Fraser. Of these Cayoosh Creek is probably the best known at the present time, and it may be considered as quite within the bounds of probability, that the terrace materials in the vicinity of the mouth of this stream, at least, will prove to justify operations on a large scale.

Van Winkle Hydraulic Mine.

Since the foregoing pages were written, hydraulic work carried out at Van Winkle Flat, about two miles above Lytton, has supplied new information on the character of the gravels of the Fraser Valley, which goes far to bear out the views previously expressed. A good hydraulic plant has been established at this place, with the object of working the whole mass of the higher terraces or benches, which rise from the river in successive steps towards the base of the mountains on the west. In 1894, an excellent section was found in the hydraulic pit, running back from the river for about 1200 feet. The character of the work is described in the summary report for 1894 (p. 17 A). The river-flat, originally worked by hand, as well as some parts of the edges of an older river-channel now about 100 feet above the stream, proved to be rich in gold; but the yield from the hydraulic workings had not, at the time of my visit, fully realized the anticipations of the owners.

It is here proposed, with the aid of the annexed diagram, and as a type of the structure of the drift materials found in this part of the Fraser Valley, to briefly explain the character of the deposits exposed.

Section seen in it.

The river-flat *(d)*, a few feet only above high-water, is not actually cut across by the line of sluices, where the first principal terrace *(c)* rises steeply from the river to a height of about 100 feet. The next terrace *(b)* is about sixty feet higher, and there are other irregular terraces at still greater heights.

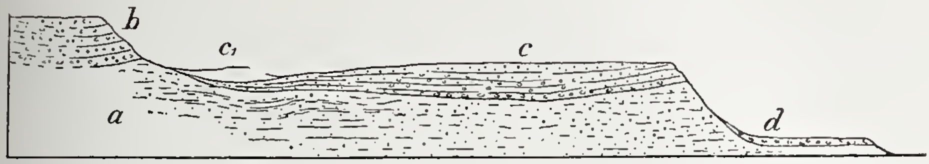

FIG. 16.—SECTION AT VAN WINKLE HYDRAULIC MINE, FRASER RIVER.*

a. Deposit formed in valley during time of flooding (White Silt period).

b. Material filling an early river-channel of the succeeding period of erosion.

c. Material filling a later river-channel of the same period, with (c^1) marginal flood-deposits of the same date.

d. River-flat covered by still later river deposits and near the level of the existing river.

No true bed-rock is seen, the bottom of the old valley being here evidently below the present river-level, nor is any boulder-clay exposed, this, as elsewhere explained, having been removed during a period of erosion antedating that of any of the deposits met with. The lowest and oldest of these deposits *(a)* consists, near the river (where it forms the greater part of the bank) of well-rolled gravels and small or medium-sized boulders, yellowish-gray in colour, irregularly and somewhat obscurely stratified and with sandy rather than clayey material filling interstices. Further back from the river, this deposit is found to change into coarse and irregularly stratified sands and fine gravels of darker colour, sometimes more or less cemented. Cemented layers of this character constitute the only approach to bed-rock so far found. This deposit evidently represents the material with which the valley was filled during a lacustrine epoch, or one in which the valley was from some cause flooded. Its surface has probably been, at least in some places, as high as the highest remaining terraces, from which it has been cut away at a later time by the river, as the stream gradually worked down to the present level. Deposits of period of filling.

Remains of old river-wash may therefore be looked for on even the highest terraces, but the highest old channel here actually cut into, is that marked *b*. This shows yellowish stratified gravels with some bouldery layers, but had not been exposed to its bottom at the time of my visit. Deposits of period of excavation.

The lower river-channel must in each case be the newer, and on the arrangement assumed in the diagram (in all probability correct) the next deposit in order of time is that marked *c*, representing the filling of another river-channel, fully exposed in the work. This consists chiefly of gray gravels with very coarse bouldery layers in the bottom, Series of old channels.

*Compare with section on Thompson River, p. 306 B.

but on the inland side, is gradually replaced by stratified sands, containing some silty and some gravelly layers, which evidently represent the flood-overflow deposits of the same period. They are indicated by the letter c^1, and the monitor stood upon them at the time the sketch was made. The gravels of the river-flat *(d)* represent a portion of the deposit made by the river at a still later date, when it had nearly reached its present level.

Contents in gold.

In gold, the older deposits *(a)* are poor, as might be anticipated from their comparatively unsorted character and the fact that no auriferous tributaries are known to enter the valley in this part of its length. The gold so far obtained, has been chiefly from the gravels marked *c*, but the quantity has been only moderately remunerative. The gravels *b*, where prospected, show evidence of more gold, but the most highly concentrated deposits of this section have evidently been those of the river-flat and of the banks and bars of the present river.

Origin of materials.

That the older material filling the valley *(a)* is largely of local origin, seems to be shown by the fact that, at a short distance below the works, a bouldery point and bar, extending across the river and crowding it against the Cretaceous rocks of the east bank, occurs in manifest relation to a small valley here entering that of the Fraser from the mountains on the west. The filling of the old channels is probably largely composed of the rearranged material of *a*, but doubtless also with the addition of much gravel trailed down by the current of the river, and the contained gold in each case must be supposed to have had the same double source.

Early placer mining.

The subject of the actual working of the gold placers of the Fraser and Thompson, has been treated in some detail in my Report on the Mineral Wealth of British Columbia.* It is now largely historical, and much information gained by the early miners in the course of their work, has lapsed beyond the possibility of recovery. Placer mining along these rivers was begun in 1857, 1858 and 1859, and the aggregate yield for these years alone, amounting to not less than $1,700,000, was derived almost entirely from these rivers, though in part from portions of the Fraser to the north and south of the present map. This mining was conducted on river-bars and benches with the rocker and by sluicing, and work of the same kind, though with less important results, has never since been entirely interrupted. The placer mining of the future along these valleys is, however, likely to be conducted by improved hydraulic methods and by dredging appliances in the river-bed.

General conditions found.

A list of the bars worked in the early years of mining on the Fraser, as complete as it was found possible to compile, is given in the publica-

* Annual Report, Geol. Surv. Can., vol. III. (N.S.), pp. 24 R–29 R, 115 R - 119 R.

tion just referred to.* Upon an examination of this admittedly incomplete list, the following observations bearing on the part of the river included in the present map, are based.—" From a point on the river a few miles below Boston Bar (about sixteen miles above Yale) to Sisco Flat, (a short way below Lytton) a distance in all of about twenty-five miles, rich deposits of 'heavy' gold were worked. Further up the river is a second run of 'heavy' gold, the limits of which can not now be so well defined, but which appears to have extended from a point about half-way between Lytton and Foster's Bar, to some little distance above Fountain. Here nuggets of some size were occasionally unearthed, and there were some exceptionally rich diggings. On the Thompson, the vicinity of Nicoamen, where the original gold discovery occurred, has always been noted for its 'coarse' gold."

Where upon these large streams the river-bars only have been mined, all signs of such mining disappear each year, in consequence of the descent of the flood-water of summer, but wherever the mining has extended to the terraces or benches, its traces remain. Thus, apart from our knowledge of the fact that almost every bar in the length of the Fraser included by the map has at one time or other been worked over, the evidences of bench mining are alone sufficient to show that this whole length has been more or less richly auriferous. Such traces are less conspicuous in the case of the Thompson River, and the evidence is that it was found to be much less continuously gold-bearing. Had we a complete plan of the Fraser, upon a sufficiently large scale, on which all the benches, with the areas occupied by solid rock and the patches upon which mining has been conducted were laid down, it would enable us to gain a pretty clear idea of the probable relations of the present stream to the pre-glacial one, both in regard to the elevation of the latter relatively to the former and to the manner in which the older concentrations have enriched some parts of the present river. No such general plan has yet been attempted, but a small part of the river which has been sketched with these points in view, is here presented as an example. It may be added, however, that to any one examining the river, with a just appreciation of the facts of its history as here outlined, the relations spoken of are quite apparent on the ground, and that these will doubtless be studied on the spot by the miner and all promising places prospected at the same time.

Auriferous parts of valleys shown by old work.

Illustration of conditions on Fraser.

It may, however, be stated, that several places were seen along that part of the river above Fountain, in which the existence of an old drift-filled channel, with rocky sides, appeared to be very probable. One of these occurs on the east side of the river opposite Black Hill Creek;

Drift-filled channels noted.

* *Op. cit.* p. 115 R. *et seq.*

another, though in this case a very short length of old channel, may occur about half a mile below Kelley Creek, on the west side of the present river; a third, where the channel is probably three-quarters of a mile in length, is two miles below the point at which the Fraser enters the map-sheet, also on the west side of the river.

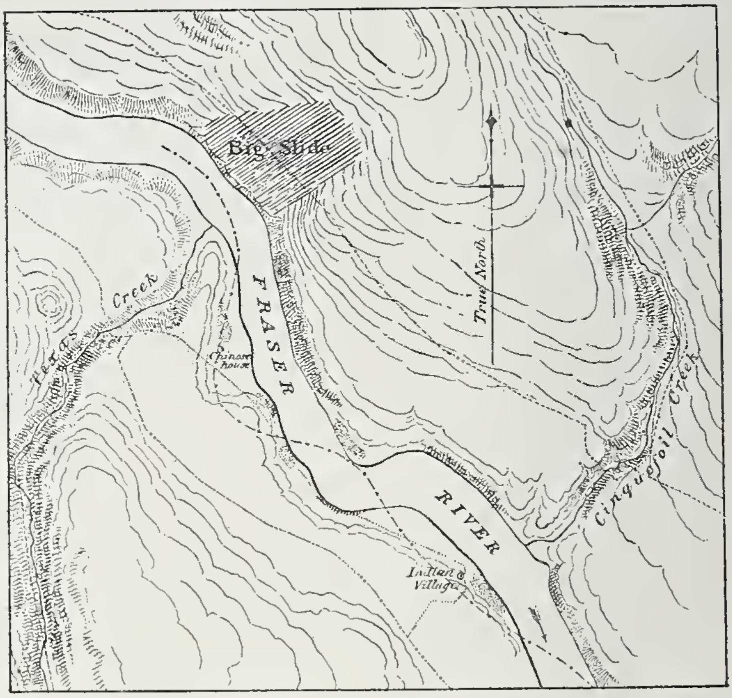

FIG. 17.—SKETCH-PLAN OF PART OF FRASER RIVER, NEAR TEXAS AND CINQUEFOIL CREEKS.

Illustrating the relations of the pre-glacial and modern channels of the river and the position of alluvial gold deposits. The probable course of the pre-glacial channel, shown by dot-and-dash line. Rocky bluffs, shown in heavy hachures; bluffs or banks of gravel, in lighter hachures. Parts of low 'benches' worked over for gold, stippled. Trails and routes shown by dotted lines. (Approximate scale, 108 chains=1 inch).

Recapitulation of placer deposits.

In recapitulation of the foregoing discussion, it would appear that the conglomerates and gravels of the district included in the subjoining list, are either known to be auriferous or may be regarded as probable or possible sources of gold. The list begins with the older deposits, but does not include the still older conglomerates of the Câche Creek and Cambrian, less regularly developed and of which no tests have been made:—

1. Cretaceous Conglomerates.—No gold yet found.

2. Oligocene Tertiary Conglomerates.—Traces of gold found.

3. Miocene Conglomerates or buried river gravels.—Not yet discovered in this district, though sandstones and water-bedded tuffaceous rocks are known in some places.

4. Early Pliocene Gravels:

a. In high-level valleys.—Buried under drift deposits wherever remaining; not prospected.

b. Along main river-valleys.—Excavated and redistributed in succeeding period.

5. Later Pliocene Gravels.—Possibly in part still remaining along Fraser, Thompson and other deep valleys, and if so, probably in some places above, in others below the present river-level. These would undoubtedly be richly auriferous, but no such deposits appear yet to have been discovered or worked by miners.

6. Boulder-clay.—In this the gold is probably everywhere too much disseminated for profitable working.

7. Interglacial gravels, silts, etc.—These have constituted most of the drift-filling of the Fraser and Thompson at one period, and still form the mass of the river-terraces—probably containing payable gold in places.

8. Gravels and bouldery deposits capping river-terraces.—These, with the gravels of the next class, have been those chiefly worked on the Fraser and Thompson. Nearly everywhere auriferous along these rivers, and often elsewhere.

9. Modern river gravels.—Nearly everywhere auriferous along the Fraser, frequently so on the Thompson, and often elsewhere.

Other Placer Deposits Worked.

Gold on other streams.

The following brief notes refer to other rivers and streams in the district, upon which gold working has been carried on. They are derived in part from the general list given in my Mineral Wealth of British Columbia.

Cayoosh Creek.

Cayoosh Creek.—This is again referred to in connection with auriferous quartz (p. 338 B). It was not discovered to contain valuable placers till 1886, but has since been continuously worked by Chinese. In the first year it yielded 725 ounces of gold. Up to 1890, inclusive, it is estimated that gold to the value of $160,000 had been obtained.*

*Report of Minister of Mines of British Columbia, 1890, p. 376.

The part of this creek which has been worked, is about five miles in length, extending from the flat land where it meets the stream from Seton Lake, as far up as the Bonanza mine. Throughout this part of its length, the valley is bordered on both sides by high mountains, and is never wide. The greater part of the gold has been obtained below the "cañon," in a length of about two miles; but the richest claims of all occurred in a distance of about 1000 feet above the "cañon," where the old rock-bottom of the stream was reached. Elsewhere it has not been "bottomed," for though still rapid, the stream has been blocked by rock-slides from the mountains, in such a manner as to lead to the accumulation of great quantities of gravelly deposits in it. All the gold obtained is coarse. The Enterprise Company of Vancouver, has been engaged for some years in endeavouring to open the lower part of the creek, just above the flat, for hydraulic working, by providing a channel deep enough to drain the old rock-bottom. In 1892 a tunnel was completed for this purpose at a cost of $25,000, and work was continued in 1893 and 1894, although with only moderate returns, much difficulty being experienced in dealing with large boulders.

Bridge River

Bridge River.—Discovered in 1858, and soon prospected nearly to its sources, some mining being done throughout. The coarsest gold is reported to be found along the first ten miles from the mouth, further on, for about fifteen miles, more or less scale gold was obtained. Still further up, the river becomes rather slack and little gold has been got, though some gold occurs in all the tributary streams. A good deal of mining has been done of late years in the vicinity of the South Fork, which is reached by a journey of three or four days from Lillooet, *via* Seton Lake and across the mountains. It is reported that one nugget weighing 32 ounces was found five miles up Bridge River, and that in 1866 twelve Chinese miners obtained gold to the value of $66,000 by wing-damming.

The part of Bridge River included by the map, flows swiftly in a deep, mountain-bordered valley not of great width, in the bottom of which the stream itself has cut a nearly vertical-sided trench, averaging about fifty feet in depth, with rocky walls. The rocks belong to the Cretaceous formation. Patches of terrace-deposits occur at various elevations up to 300 or 400 feet above the water, those at lower levels being flat, while the higher ones slope toward the axis of the valley.

Bonaparte River.

Bonaparte River.—More or less placer mining has occurred along the lower part of this stream, below Câche Creek. On its tributaries, *Hat Creek* and *Scottie Creek*, gold has also been found, but in small

quantities. The lower deposits of an old valley, which leaves the Bonaparte three miles above its mouth and is followed southward by the wagon-road, may be worthy of examination.

Tranquille River.—Gold was discovered here in 1858, and appears to have been worked with little interruption ever since, chiefly by Chinese. For many years, twenty to thirty Chinese have been continuously employed here, but latterly the number has decreased and the earnings are now supposed to be small. The gravels worked are those of the bed and banks of the streams, with narrow flats adjacent to it, but in 1893 the miners began to pay attention to the benches on the west side of the creek. Arrangements have also been made by a company to begin hydraulic work on the gravels along the east side of the valley. Gold is said to have been found for a distance of eight miles in all up the stream, but the working has been practically confined to a length of three or four miles of the lower, narrow and cañon-like part of the valley. The gold is scaly and a little platinum is associated with it. Even the narrow lower part of the valley still holds considerable masses of gravels interstratified with silts, with which it has at one time been filled. These belong to No. 7 of the classification given on page 329 B, and may be found to contain sufficient gold for hydraulic working. Tranquille River.

The origin of the gold in this valley is somewhat obscure. The main stream apparently flows throughout upon Tertiary volcanic rocks which can scarcely be supposed to be auriferous. Its branch, Watching Creek, drains a considerable area of argillites, etc., holding some quartz-veins, but the gold has not been traced up to this branch. It is possible, however, that in some places the lower part of the river may reach older Tertiary gravels, like those of which remnants are found on the Garde Lafferty. It is also possible, that gold has been carried into the valley from the slaty rocks or conglomerates of the Garde Lafferty by means of the cross valley from Lac le Bois or that of Pass Lake, while the last-mentioned old valley may itself still contain gravelly deposits of later Pliocene age. (p. 320 B.) Source of gold.

Nicola River.—Scale gold may be found along all that part of the Lower Nicola included in the map, but no work of importance has ever been done and the quantity of gold is probably small. Nicola River.

Upper Nicola River.—Gold was found and worked to a limited extent on this stream in 1887, just above Douglas Lake. The gold was course and was found upon bed-rock, but only on sloping surfaces, as no attempt was made to reach the bottom of the old valley. Some gold has also been found along the river between Douglas and Nicola

lakes, but it was probably unremunerative, as very little work was done. It is noteworthy, however, that all this part of the country has been very little prospected, though the abundance of slaty rocks with quartz-veins and their proximity to the granites, would seem to render it promising.

North Thompson.

North Thompson.—No part of this river within the limits of the present map, appears to have been found to yield much gold. Some of the river-bars at one time paid to work, particularly along the lower part of the river.

The following tributaries of the North Thompson are known to have yielded more or less gold.

Tributaries of North Thompson.

Jamieson Creek.—Some mining was formerly done on the lower parts of this stream. The gold is probably locally derived from veins like those elsewhere described (p. 336 B.)

Louis Creek.—It is reported that gold to the value of $8 to $10 a day to the hand was obtained here in 1861. Chinese and other miners have occasionally worked here since, chiefly in and just below the cañon, near the mouth of the creek. Higher tributaries to the south-eastward considered promising.

Barrière River.—Mining is reported to have occurred on this stream on a limited scale in 1861, but no particulars can be obtained. Running across between the Barrière River and Louis Creek, about two miles to the east of the North Thompson, is a well marked high valley. This is continued also to the north of the Barrière for some miles, when it runs out obliquely on the edge of the North Thompson valley. It reaches Lewis Creek above the head of the little cañon referred to on that stream. This valley is partly filled with drift deposits, but its rocky bed is probably about 300 feet above adjacent parts of the main river. It appears at one time to have been occupied by a pre-glacial representative of Louis Creek and possibly by the North Thompson, at a still earlier period. I was informed, that coarse gold has been obtained in the small stream which now runs northward out of this valley to the Barrière. If auriferous gravels should be found to remain in the bottom of this old valley, these might be worked by drifting, with free drainage.

Deadman River.

Deadman River.—A Chinese company worked for a season about the mouth of Criss Creek, but as the operations were not continued, the ground may be assumed to have proved poor.

Ray Creek.

Ray Creek.—'Prospects' of fine gold are stated to have been obtained on the lower part of this stream, near its confluence with Gui-

chon Creek. There is a notable development of gravelly terraces here, with a good head of water, but it is doubtful whether the gravels are rich enough to pay for work.

Cherry Bluff Creek.—Gold has also been found here and some work was at one time attempted, but without important result. Cherry Bluff Creek.

GOLD- AND SILVER-BEARING VEINS.

Notes respecting a number of massive deposits, found to contain more or less gold, have already been given (p. 311 B); what follows relates to auriferous and argentiferous veins.

Stump Lake and Vicinity—

The metalliferous deposits found in the neighbourhood of Stump Lake, upon some of which a good deal of work of a preliminary character has been accomplished, are generally spoken of as the "Nicola mines." The geological character of the district, with the nature of the country-rock, the general course of the veins and the area within which the actual discoveries are comprised, have already been noted (see p. 130 B). "Nicola" Mines.

The metalliferous veins already known in this somewhat limited district are numerous, and while it is perhaps probable, from their very number, that no individual lode will be found to possess great continuity, the work done is sufficient to show that a considerable permanent output of ore may be obtained. The recognized veins vary in width from about 10 inches up to about 5 or 6 feet, and some of them have been traced for lengths of several hundred feet and to depths of 100 to 400 feet.

The mines and prospects in this district were visited by me in 1888, 1889 and 1890, and some account of them has been given in the summary reports for 1888 and 1890, as well as in the Mineral Wealth of British Columbia.*

The vein-matter generally consists of white quartz, containing iron-pyrites, copper-pyrites, galena, blende and tetrahedrite, with a varying, but on the whole very satisfactory content of silver and gold. The following are assays of these ores made in the laboratory of the Survey. It is not always possible to attach these to the particular claims from which they were derived, the specimens having been obtained for the Vein-matter.

*Annual Report, Geol. Surv. Can., vol. III. (N.S.). p. 69 R.

most part during the early stages of the prospecting and before my visit to the locality.*

Assays.

Locality.	Gold.	Silver.
	Ounces.	Ounces.
One of the Hepburn claims	0·759	406·574
Nicola Mining and Milling Co	0·729	104·721
Near Stump Lake	distinct trace.	20·339
" "	6·096	90·650
" "	0·792	15·094
" "	1·969	17·063

Ounces to the ton of 2,000 lbs.

Though scarcely any work has been done upon these deposits since 1890, partly in consequence of the general depression in mining matters, but in this instance also because of special difficulties of other kinds which have affected some of the companies chiefly concerned, there can, I believe, be no doubt that this district will ultimately become a mining centre of some little importance.

The following memoranda, referring to several of the principal properties and claims, are extracted from my notes, and may serve to give some idea of the general features of the deposits. No large-scale map or plan is yet in existence upon which the several claims can be definitely laid down.

The claims of the Nicola Mining Company and of the Star Mining Company are situated on and near Mineral Hill, between the wagon-road and the southern part of Stump Lake. Three principal openings, all shafts, have been made by the Nicola Mining and Milling Company

Joshua Shaft.

as follows :—*Joshua Shaft.*—The lode here opened runs about N. 10° W. on the average, but turns rather more to the west when followed northward and somewhat more to the east in a southery direction. It varies from about 10 inches to 5 feet in width and probably averages about 30 inches. It dips eastward near the outcrop, but becomes nearly vertical in depth. The rocks bordering the vein are considerably dolomitized, as is usually the case with veins in this district. The ore, like most of the others, shows iron- and copper-pyrites, galena and blende in a matrix of white quartz. Height of the head of the shaft above Stump Lake, about 420 feet. At the close of the year 1889, according to the report of the Minister of Mines for British Columbia,†

*Annual Report, Geol. Surv. Can., vol. III. (N.S.) pp. 38T and 40T.

†Annual Report of the Minister of Mines, British Columbia, 1889, p. 290.

the main shaft was 400 feet deep. Air-shaft connecting with 100-foot level 85 feet. Total length of drifts at 100, 200 and 300-foot levels 745 feet. *Tubal Cain Shaft.*—The lode upon which this is sunk runs about N. 5° W. with an easterly dip at angles of from 60° to 70°. The ore resembles the last. In 1889 the main shaft had attained a depth of 220 feet. Air-shaft 40 feet. Total length of drifts and tunnels 1350 feet.* *King William Shaft.*—The deposit upon which this is sunk has not been traced far upon the surface, but is a strong lode in depth, with an average thickness of six feet, running about N. 10° W., with a very high easterly dip or nearly vertical. In 1889 the main shaft was 175 feet deep, air and other shafts 75 feet, total length of drifts 202 feet.†

Tubal Cain Shaft.

King William Shaft.

The Star Mining Company had opened shafts upon two lodes, to the west of those above described. *Star Shaft.*—Is at a height of 200 feet or more above the lake, on a lode which runs about N. 5° W., and dips at an angle of 60° to the eastward, with a width of from 2 to 5 feet. The ore, which is of the usual character, is often distinctly ribboned, and is very little oxidized at a short distance below the surface. In 1888, this shaft had a depth slightly exceeding 100 feet, but was closed down in 1889 when the small crushing and concentrating mill which had been erected was burnt. *Planet Shaft.*—This was about 40 feet in depth only in 1888, and was closed at the same time with the last. The lode runs about N. 10° E., with an easterly dip, at an angle of about 70°. It has a width of 5 feet or more near the surface, but varied in this respect when followed down. The character of the ore here met with, differs somewhat from that seen in any other deposit of this vicinity. It has originally consisted of quartz with iron- and copper-pyrites and some galena, but the vein has subsequently been re-opened, and brecciated, and a cement of brown-spar and chalcedony has been introduced. The sulphides have at the same time become much oxidized, and considerable quantities of blue and green copper carbonates have been formed. This subsequent action may probably be attributed to the period of Tertiary volcanic activity.

Star Shaft.

Planet Shaft.

Mary Reynolds.—(J. Hepburn & Co.)—This is one of the "Hepburn Claims," and probably that to which the assay previously quoted refers. It is situated about two miles up the valley of Scott's Creek, on the north side. The lode is about 4 feet wide and very well defined, nearly vertical, and running N. 15° E. through a country-rock of porphyritic green diabase. It has been traced on the surface for 300 feet or more. According to the British Columbian Mining Report,

Mary Reynolds.

Ibid., p. 290. †*Ibid.*, p. 291.

there were at the end of 1889 three shafts on this vein, 100, 75 and 35 feet deep respectively, with 90 feet of drifts. *Dunsmuir.*—Situated about 500 feet west of the last, on a lode running about N. 5° W. and two feet or more in width, nearly vertical. Considerably decomposed where opened, but otherwise resembling the ore of the Mary Reynolds.

Dunsmuir.

The following prospects are situated some distance to the south of the last two. They have been developed to a limited extent by sinking and costeaning upon the outcrops.

Various smaller openings.

British Empire.—A well defined lode about 5 feet wide, running N. 15° W., with a dip at angles of 70° to 80° to the eastward. Pyrites and galena are rather sparingly disseminated through the quartz.

Zeila.—This lode runs about N. 15° E., with a dip to the eastward of 45° at the surface, but becoming more nearly vertical at the bottom of a shaft 27 feet deep. Iron-pyrites is the most abundant visible metallic mineral, but galena and blende also occur. The wall-rock is a porphyritic green diabase with rather abundant pyrites crystals scattered through it.

Ardmore.—This claim adjoins the north end of the last. The lode runs here N. 38° W., and is called a 'cross lode.' It is about 15 inches wide and shows some pyrites and galena in openings about 200 feet apart.

Jennie Long.—Situated about half a mile south-east of Rockford post-office. This runs about N. 85° E., and had been opened to a depth of 66 feet at the time of my visit in 1888. The greatest width seen in the shaft was about 20 inches. It is somewhat irregular in dip, but not far from vertical.

A certain amount of prospecting work has been done on many other claims, but some of these it was not possible to visit in the time at my disposal, while in the case of others, no well-defined lodes had been developed by the work done.

Jamieson Creek.—

Lodes on Jamieson Creek.

The metalliferous veins found in this vicinity, fifteen miles up the North Thompson on the west side of the river, occur in a mass of greyish granite which here breaks through the Palæozoic argillites (see p. 245 B). A number of claims have been taken up and a little surface work has been done on some of them, but I am unable to add much to the notes already given on these deposits in the Summary Report for 1888, as the locality was visited by me only in that year and no further work of any importance seems to have been done on any of the claims since.

The granite is considerably decomposed and in the vicinity of the veins is highly siliceous. The veins themselves are composed of quartz, sometimes holding fragments of granite and showing pyrites, with a little galena, blende, and tetrahedrite. It is probable that the date of origin of the veins is contemporaneous, or nearly so, with that of the intrusion of the granite mass, and that its silicification and decomposition happened concurrently with the segregation of the vein-quartz, which often forms irregular stringers characterizing certain zones of the rock.

The larger veins, so far as exposed, appear to run nearly due north-and-south. One of these, uncovered on the north side of the valley of the creek, about 700 feet above the stream, was found to be 10 feet thick. It had been traced for a distance of 200 feet, where a second small opening had been made which showed from 4 to 5 feet of vein-matter. In a second locality, on the face of the hill, near a log cabin built by the prospectors, the deposit opened up consisted of a system of irregular quartz-veins, some of which occasionally became several feet in thickness. On the top of the hill, about 70 yards north of the last locality, and possibly in continuation of the same deposit, some shallow costeaning pits showed as much as 6 feet of vein-stuff. Openings examined.

I was unable to identify the several claims by name, as no one connected with the work could be found at the time of my visit, but the generally high character of the ore is shown by the following assays, made in the laboratory of the Survey from the specimens received.*

Assays.

Name of Claim.	Gold.	Silver.
	oz.	oz.
Home Stake	1·108	34·243
Silver King	0·583	2·525
Silver Queen	0·758	28·992
Kamloops	0·700	25·200

Ounces to the ton of 2000 pounds.

The deposits met with in this locality certainly appear to deserve some further examination. It seems not improbable, that by operations partaking, in the first instance at least, more of the nature of quarrying than mining and not strictly confined to the wider veins, large quantities of ore of medium grade might here be obtained.

*Annual Report, Geol. Surv. Can., vol. IV. (N.S.), p. 60 R.

Cayoosh Creek.—

Lodes on Cayoosh Creek.

The source of the placer gold of this stream is evidently quite local, for coarse rough gold containing quartz has frequently been found in it. Mr. A. W. Smith, M.P.P., showed me, in 1889, several pieces of such gold mixed with quartz, one of which was estimated to contain several ounces of gold. The gangue in this case was about half quartz and half white calcite, through both of which the gold penetrated indifferently. Discoveries made subsequently to that of the placer mines, leave no room for doubt that the gold has originated from quartz-veins traversing the argillite-schists of the adjacent mountains, and a number of claims have been staked out on these. Specimens from several of them show visible gold, and many others yield gold in fine particles when roasted, crushed and washed. The best known and first discovered (1887) of the quartz properties upon this creek, is that named the *Bonanza*, in which several claims have been consolidated. Some very rich specimens of auriferous quartz have been obtained from this place, though the gold is more usually minutely and uniformly distributed through the quartz. A considerable amount of prospecting work has been done, but so far without leading to the establishment of any regular mining. The quartz-veins occur in the schistose series of rocks which forms considerable tongues and infolds in the granite of this part of the Coast Ranges and is referred to in greater detail elsewhere. (See p. 99 B.)

Bonanza claims.

The Bonanza claims are situated about seven miles up Cayoosh Creek from its mouth, on the steep mountain side on its right, or south bank. Numerous small quartz-veins here run with the strike of the black argillite-schists, generally about south-east by north-west, and usually following the dip of the rocks to the south-westward, but sometimes cutting across it. Few of these veins individually exceed a foot in thickness and some are much less. At the time of my visit, in 1889, the lowest work done, at about 390 feet above the creek, showed a face of say 30 feet in width, charged with broken and irregular small veins separated by crushed and displaced schists. Several tons of quartz had been taken out and piled here. Further up the very steep slope, (about 910 feet above the creek) a tunnel was being run in to intersect several quartz stringers seen at a greater elevation, from which rich specimens containing gold had been obtained. The length of the tunnel was then 160 feet, but was subsequently increased. Still further up (about 1410 feet above the creek) a shaft some 60 feet in depth had been sunk on a rather irregular vein, which in places showed 2 feet 5 inches of quartz. It would appear, that the best method of fairly testing this deposit, would be to endeavour to

work one of the zones characterized by numerous small quartz-veins, going back, at least in the first instance, from a natural face, and making no attempt to follow the veins by underground work. A small stamp-mill to treat the quartz obtained, would enable a trustworthy estimate to be made of the average quantity of gold likely to be secured on the large scale.

Other claims among the mountains of this vicinity were not visited, but from the specimens obtained and descriptions given, they appear closely to resemble the above, and the amount of free gold which several of them contain, is encouraging to the belief that some, at least, of them, will eventually be found to be profitable in regular mining operations. Other claims

Specimens from these claims assayed in the laboratory of the Survey, have yielded the following results.*

Assays.

Name of Claim.	Gold.	Silver.
	oz.	oz.
Bonanza	0·991	0·058
Crown Point	0·992	None.
Crown Point	0·722	None.

Ounces to the ton of 2000 pounds.

Big Slide Mine.—

The Big Slide mine, is situated on the bank of the Fraser, at the mouth of Kelley Stream. This stream falls very rapidly to the Fraser in a steep and rough gorge, and a good deal of labour was spent in constructing a tramway down this gorge to the mine. The mining operations were chiefly carried on in 1886, when a number of tunnels and drifts were made and a ten-stamp mill, with concentrator and chlorinating furnace was erected. All work was, however, suspended in 1887 and it has not since been resumed. Big Slide Mine.

The rocks observed in this locality have already been noticed (p. 93 B). The vein upon which the work was done, is several feet in thickness and can be seen in the cliffs for a height of 300 or 400 feet at least. It runs with considerable regularity on a bearing of S. 45° E. with a north-eastward dip at an angle of about 70°. The material is quartz, containing iron-pyrites and a little copper-pyrites, and there appears to be no doubt that the ore can be obtained in considerable

* Annual Report, Geol. Surv. Can., vol IV. (N.S.), pp. 58 R, 59 R.

quantity. I was informed that difficulty had been found in saving the more valuable parts of the ore by the process of concentration employed, but whether or not this arose from unskilful work in the mill is not known. A specimen of the concentrates remaining in the mill at the time of my visit, in 1889, was subjected to assay in the laboratory of the Survey, with the following result :—

Assays of concentrates.

Gold....	0·408	oz. to the ton of 2000 lbs.
Silver........................	0·933	" "

The occurrence of the metalliferous vein at this place is pretty evidently in connection with the granitic mass of the vicinity (pp. 78 B, 242 B) having probably resulted from the hydrothermal action set up at the time of its intrusion. Further deposits of a similar kind may occur elsewhere along the same line.

OTHER MINERALS AND ORES.

Cinnabar on Copper Creek.

Mercury.—What may prove to be an important deposit of cinnabar, has lately been found in the vicinity of Copper Creek, Kamloops Lake, and several contiguous claims have been taken up on this, on the west side of the valley of the creek, near its mouth. The claims have, I believe, been combined in a single property, but the best looking deposit of ore occurs on the *Rosebush* claim, where a shaft about fifty feet deep, connecting below with a drift more than fifty feet long, had been opened. The height of this place is about 450 feet above the lake. Other small openings had been made in the same vicinity, as well as a second shaft, thirty-five feet deep, on the *Yellow Jacket* claim, about a quarter of a mile northward of the Rosebush.

Mode of occurrence.

The cinnabar occurs in irregular sparry veins, consisting chiefly of calcite and quartz, with some dolomite, traversing zones of a gray felspathic and dolomitic rock which readily weathers to a yellowish colour. Both these zones and the contained veins, as a rule, run nearly magnetic north-and-south through the main rock of the hills, which is a dark greenish-black, Tertiary eruptive, containing pyroxene and olivine—but much decomposed. A considerable quantity of rich ore has been taken from the wider portions of the main vein opened on the Rosebush. Although the slopes of the hills are abrupt, they are almost everywhere covered with drift deposits, and much more work is necessary in order that the true value of the deposit may be ascertained. Exploratory trenching in an east-and-west direction would be the most economical method in the first instance. A little antimony sulphide (stibnite) is observable in some parts of the ore.

Another claim, upon which very little work has been done, is the *Last Chance, No. 2*, situated on the east side of Copper Creek, near the junction of the Tertiary volcanic rocks with a small area of decomposed granite. Small quantities of cinnabar are found here, and some narrow seams of molybdenite also occur. In the adjacent granitic mass (p. 174 B), minute bright-red specks of cinnabar may also be detected, and it would appear that the extensive decomposition of the basic volcanic rocks of this region, by heated waters or steam, has led to the diffusion of a certain quantity of cinnabar through some parts of both classes of rocks, and to its concentration in some of the veins.

Decomposition of a similar character, has affected the rocks seen on the opposite side of Kamloops Lake, along the railway, to the east of the mouth of Cherry Bluff creek. No cinnabar has been observed here, but distinct traces of cinnabar are found in seams cutting some of the rocks at Six-mile Point, also on the south shore, but further to the west. I have also been informed that grains of cinnabar have been observed in washing for gold on Criss Creek, to the north. Possible extent of the deposits.

These occurrences, taken together, indicate that search for cinnabar may be made with some prospect of success over a considerable area in this vicinity.*

Platinum.—The occurrence of minute scales of platinum, with gold on the Tranquille, has already been alluded to. It is also stated to have been found in the same manner on the Fraser, particularly at a place ten miles below Lillooet, but there are no indications of its existence in quantities of economic importance in this district. Platinum.

Native Silver.—This metal is also occasionally found in the native state in gold-washings, particularly near Nicoamen on the Thompson, where pellets of considerable size are reported to have been discovered in 1858 and 1859. Native silver.

Iron.—The occurrence of considerable quantities of magnetic iron-ore, and the general conditions under which it is found, in the rocks composing Cherry and Battle Bluffs on Kamloops Lake, are elsewhere mentioned (p. 157 B). The largest of these deposits which have been discovered, lie near the west end of Cherry Bluff. These were noted in my Report of 1877, and an assay by Dr. B. J. Harrington is there quoted which shows the ore to contain 66·83 per cent of metallic iron, with very little phosphorus or sulphur.† Magnetite at Cherry Bluff.

*Since the above was written, further work has been done upon several of the claims, with results said to be satisfactory. Cinnabar has also lately been found in rocks about four miles further up the Copper Creek valley, on its west side.

†Report of Progress, Geol. Surv. Can., 1877-78, p. 118 B.

A property covering the principal known deposits near the west end of Cherry Bluff, with an area of 200 acres, was secured in 1889 by Mr. J. W. Mackay and named the *Glen Iron Mine.* The ore deposits have since been developed to some extent and worked intermittently, producing, according to the reports of the Minister of Mines of British Columbia, an aggregate quantity of 4700 tons, up to the close of the year 1894. The ore has been shipped to the coast and most of it to the State of Washington.

Note by Mr McEvoy

In the autumn of 1892, the Glen Iron Mine was visited by Mr. McEvoy, who gives the following note on the deposits uncovered at at that time.*

"The ore is magnetite throughout, with a slight mixture of calcite and felspar in a few places, which, however, does not injure the ore for smelting. The following items were noted :—

"1. An opening a few feet from the railway, filling an irregular angular fissure from two to six feet in width.

"2. Three hundred feet south of last, a deposit of four feet of good ore, with five feet mixed ore and country-rock.

"3. Five hundred feet southward from last, a large deposit of fourteen feet good ore, with ten feet of mixed.

"4. Thirty feet north-west of last, twelve feet ore.

"5. West of last a vein three feet thick.

"6. South-west of last, numerous croppings of good ore undeveloped. At a low estimate ten per cent of the mass here is ore.

"7. North-east of No. 3, a vein four to ten feet thick. This is the principal source of output at present and is connected with the railway by an aerial tramway.

"All the veins run in an easterly and westerly direction, and are nearly vertical or dipping northward at high angles."

Mode of occurrence.

A short visit was again made to the mine by the writer in 1894, but no work was then in progress. The veins, or lenticular and alternating masses of ore, do not appear to be of the nature of a segregation from the enclosing eruptive rocks. The walls are often distinct, and the ore contains in some places brecciated fragments of the surrounding rocks, as well as imperfectly developed crystals of white felspar, and occasionally is associated with much epidote. It is evident that a large quantity of good ore may easily be obtained at this place. A specimen of impure ore, consisting chiefly of a mixture of magnetite and

*Quoted from the Summary Report, Geol. Surv. Can., 1892.

hornblende, was examined for silver and gold in the laboratory of the Survey, but proved to contain only a trace of gold with 0·116 ounce of silver to the ton of 2000 lbs.*

Magnetic iron-ore is also known to occur near Watkinson's, about twenty-three miles above Lytton, on the Fraser River, where the vein is reported to be 20 feet in thickness.

Magnetite and iron-pyrites are found, apparently in considerable mass, in a ravine upon which a saw-mill was at one time situated, about half a mile below Nicoamen. The ore contains too much pyrites to be of value and on assay it proved to hold no gold or silver. Other occurrences of iron-ore.

Copper.—The vicinity of Copper Creek, Kamloops Lake, has been known to the Indians from time immemorial as a place of occurrence of native copper, but the precise locality had been lost.† Native copper.

Specimens have, however, since been obtained from the Painted Bluffs, to the east of the creek, in which small grains and thin plates of copper appear. This occurs both in the mass of the rotten serpentinized rocks, and in dykes of now serpentinous trap cutting it. It is scarcely probable that deposits of a workable character will be found, but it was doubtless from such occurrences that the Indians derived their supply.

In 1888, a couple of claims which had been staked out on the east side of the creek about half a mile back from the lake, were visited. A small opening had been made which showed a shattered zone in the brown porphyritic trap of the vicinity, holding small quantities of copper-ores, largely decomposed. A specimen subjected to assay proved to contain no gold, and only 1·458 ounce of silver to the ton.‡ Since then, another claim named the *Tenderfoot*, has been taken up at the same place, and some prospecting work has been done, resulting in the discovery of a vein from twelve to fifteen inches thick, holding some quantity of bornite, in a gangue of dolomite, with some white felspar. The vein, so far as exposed, is a very irregular one, but the amount of work done upon it was quite inconsiderable. Bornite.

Near Watkinson's, Fraser River, about 23 miles above Lytton, gray copper (tetrahedrite) is reported to occur in considerable mass. A specimen assayed in the laboratory of the Survey, contained a trace only of gold and 5·833 ounces of silver to the ton of 2000 lbs. Other occurrences.

In association with magnetic iron-ore at the west end of Cherry Bluff, copper-pyrites occurs, but probably in small quantity.

* Annual Report, Geol. Surv. Can., vol. V. (N.S.), p. 58 R.

† Report of Progress, Geol. Surv. Can., 1877-78, p. 116 B.

‡ Annual Report, Geol. Surv. Can., vol. IV. (N.S.), p. 63 R.

At the Great Rock-slide, Thompson River, small quantities of copper-ores are found.

On the Thompson River, six miles below Spence's Bridge, rich specimens of purple copper-ore have been found in the drift, and at nine miles below the bridge a rough fragment of native copper, weighing several ounces, was found.

On the Fraser River, ten miles below Lillooet, and again on Eleven-mile Creek, pieces of native copper have been discovered.

In many of the ores of the district, notably in those of the vicinity of Stump Lake, copper-pyrites is an important constituent, but must be considered as subsidiary to the precious metals contained in these ores.

Lead.

Lead.—Galena occurs as a constituent of some of the ore-deposits, particularly in those of the vicinity of Stump Lake, but is nowhere known in the district in such quantity as to constitute a lead-ore by itself.

Antimony.

Antimony.—Stibnite occurs near Watkinson's, about 23 miles above Lytton, on the Fraser. The vein is reported to be about 14 inches wide, with quartz and calcite. The stibnite holds traces of gold and 2·187 ounces of silver to the ton of 2000 lbs.

Age of coals and lignites.

Coal and Lignite.—The deposits of coal and lignite found in the area of the Kamloops sheet, are confined to the rocks of Tertiary age, and the more important of them appear to belong to the older portion of the Tertiary which has been provisionally classified as Oligocene, though, as elsewhere mentioned, there appears to be a possibility that coals of Cretaceous age may yet be discovered (p. 66 B).

Causes of difference.

Some of the known fuels are true coals and yield firm cokes, while others are lignites, incapable of producing coherent cokes and containing a much larger percentage of water. This difference does not appear to depend so much upon the actual geological horizon at which the fuels are found, as upon the different degree of alteration to which the strata have been subjected after their deposition, in consequence of local causes, and perhaps to some extent upon the different composition of the vegetable material itself at the time of its inclusion. Thus the fuels met with on the North Thompson and in the lower or 'main' seam on the Nicola, both of which are supposed to be Oligocene, are coals, and that met with at Kamloops is also a coal, though included in the Miocene rocks, while the upper seams of the Nicola with that of Hat Creek (also believed to be Oligocene) are ordinary lignites.

Details already given.

The mode of occurrence, as well as the known or possible extent of the several deposits of coal and lignite, are so closely connected with the

stratigraphy of the formations in which they are found, that all details respecting them have been incorporated in foregoing pages of the Report.

Nicola-Coldwater field.

The places of occurrence of coal upon the Nicola, near the mouth of the Coldwater, lie beyond the edge of the present map, but inasmuch as the extensions of the same basin enter the southern part of the map, some references to the known localities to the south are included in that part of the Report which deals with the Tertiary rocks of the Nicola Valley. Further particulars, with a section, may be found in the Report for 1877-78 (pp. 123 B, 127 B). Borings recently made in this vicinity, have afforded further evidence of the value of this coal-basin, and it is hoped that with the aid of these, and the better knowledge now gained of the Tertiary rocks as a whole, it may soon be possible to work out the structure of this basin in greater detail. It is the only locality in or near the Kamloops sheet in which a true coal of actually known workable thickness has yet been found.

References to localities.

The following list of localities in which coals or lignites are known to occur, will serve as an index to the pages of the Report upon which a description of these occurrences may be found :—

North Thompson, near the Indian Reservation. *Coal*, p. 229 B.

Near Kamloops. *Coal*, p. 168 B.

Nicola Valley. *Coal and lignite*, p. 190 B.

Guichon Creek. *Lignite*, p. 192 B.

Hat Creek. *Lignite*, p. 207 B.

Bonaparte River, between Câche Creek and Ashcroft. *Lignite*, p. 213 B.

Thompson River, near Nicoamen. *Lignite*, p. 184 B.

Fraser River, below Lytton. *Lignite*, p. 188 B.

Red Point, Kamloops Lake. *Lignite*, p. 167 B.

Asbestus.

Asbestus.—Small veins of chrysotile or serpentine asbestus, have been observed in or near some of the deposits of serpentine contained in the Câche Creek rocks, especially in the vicinity of the Fraser River, between Texas Creek and Bridge River, and in the southern base of Mount Soues, near Junction Valley. It is possible that workable deposits of asbestus may yet be found in these rocks, but the specimens so far obtained are too small and too short in the fibre to be of any economic value.

Structural materials.

Building and Ornamental Stones.—Nearly all the rocks met with in the region, are so much fractured and jointed as to be incapable

of yielding good stone for masonry. There are no easily dressed free-stones, and the limestones are invariably greatly shattered. The granites, and some of the basaltic and other volcanic rocks of the Tertiary, are alone capable of affording good blocks of any considerable size, and of these only those which occur in the vicinity of the railway, or near to navigable waters, can be considered as possessing any great importance. The granites of the Coast Ranges are those best suited for purposes of construction, but these can be obtained most easily to the south of the present sheet.

The marbles, in which form the limestones are not seldom found, are too much shattered to be considered of value for polishing, and the same remark applies to the serpentines.

Brick clays.

Brick Clays.—Clays or silty deposits suitable for the manufacture of ordinary brick of fair quality, may be obtained from the alluvial deposits or lower benches of many of the larger valleys. The White Silts (p. 283 B) afford an unlimited supply of material from which fine, cream-coloured or fawn-coloured, hard bricks may be made, but the scarcity of fuel for burning bricks near the line of railway, detracts from the value of these silts for this purpose.

Lime.

Lime.—Limestones suitable for burning, are, as will be gathered from the map and from the foregoing descriptions of the rocks, extremely abundant, but to be readily utilized they must be situated on navigable waters or on the line of railway. The limestones most easily accessible from Kamloops and suitable for this purpose, are found near Venn's, seventeen miles up the North Thompson, on the west side; opposite the mouth of Campbell Creek, ten or eleven miles up the South Thompson from Kamloops, on the north side of the river, and near the mouth of Three-mile Creek, to the south of the railway. These and other localities nearest to the various settlements are indicated upon one of the maps accompanying this report.

China-stone near Spatsum.

Opposite Spatsum station, on the west side of the Thompson, a mass of remarkably decomposed rocks occurs. So far as could be observed, the area of great decomposition is about half a mile long by quarter of a mile in width. The state of the rocks at this place is only a special case of the alteration which has affected a great belt of strata along this part of the river, as elsewhere noticed (pp. 79B, 115B). It is evidently related to the margin of the great granite mass on the east and to the faulting which has occurred here. The rocks have, in the first place, been thoroughly decomposed and pyritized, probably by the action of heated waters or steam, and subsequently more or less completely leached out by acid waters resulting from the oxidation of the pyrites. The soft resulting

material has been cut out in several steep gullies, where it appears as crumbling banks of red, yellow or white tints, upon which scarcely any vegetation grows. Some parts of these are almost purely siliceous, others consist of mixtures of quartz and kaolinite in varying proportions, often with a perceptible efflorescence of soluble salts of a styptic taste. The white and thoroughly leached rocks are those which have attracted attention as china-stone, and in these, kernels and veins of pure white gypsum sometimes occur. It is doubtful, however, whether any considerable quantity of china-stone could easily be quarried free from iron stains, while the china-clay or kaolinite could only be obtained in a pure state by the crushing and washing of the mass.

It is probable that parts of this deposit might advantageously be employed in the manufacture of fire-bricks. Specimens of the highly pyritous rock were assayed, but proved not to contain any gold. Possibly useful for fire-brick.

Agates and Chalcedony, are found in considerable abundance in some parts of the extensive tracts characterized by Tertiary volcanic rocks, particularly those occupied by the upper part of the Tertiary. The colours are usually pale, but many examples are prettily striped and banded. Green tints are not uncommon. The Nicoamen Plateau and that in the vicinity of Savona Mountain, with the neighbourhood of Dufferin Hill near Kamloops, are among the places where agates were found to be particularly numerous, but their occurrence and character depend on combinations of conditions which are always more or less local. *Hyalite* or Muller's glass, occurs in basaltic rocks near Hi-hium' Lake (p. 220 B) and it is quite within the bounds of possibility that precious opal may be found in some of the volcanic rocks of the district (p. 233 B). Agates. Hyalite and opal.

Jade or Nephrite, formerly much prized by the Indians for the manufacture of adzes, occurs as pebbles or small boulders along the Fraser and Thompson rivers. It has been observed by me in this form near Lytton and near Spence's Bridge, but has not yet been found in place. Worked fragments and adzes, or portions of adzes, may occasionally be found in the vicinity of old Indian burial places. I have described these occurrences elsewhere.* Three specimens of these nephrites have been analysed by Dr. B. J. Harrington.† Jade.

Mineral waters.—Many small saline springs occur in this district which are due merely to the accumulation of salts in the superficial Carbonated mineral water.

*Note on the Occurrence of Jade in British Columbia, Canadian Record of Science, vol. II., 1889, p. 364. Notes on the Shuswap People of British Columbia, Trans. Royal Soc. Can., vol. IX., sect. II., p. 18.

†Trans. Royal Soc. Can., vol. VIII. sect. IV., p. 51.

deposits of the drier valleys, and a number of the small pools and lakelets without outlet, are charged with similar salts, but the only known mineral spring of any possible importance, is situated on Maiden Creek, four or five miles west of Mundorf's. This is described by Mr. A. Bowman as being charged with carbonic acid. A qualitative analysis of its water has been made in the laboratory of the Survey.*

* Annual Report, Geol. Surv. Can., vol. II. (N.S.), p. 13 T.

APPENDIX I.

PETROGRAPHICAL CHARACTERS OF SOME ROCKS FROM THE AREA OF THE KAMLOOPS MAP-SHEET, BRITISH COLUMBIA.

BY

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INTRODUCTORY NOTE.

The nomenclature adopted in the following descriptions is, in general, that of Rosenbusch, as given in the second edition of his "Massige Gesteine," but classification based on the age of the rocks has not been strictly adhered to.

Owing to the extreme alteration of some of the specimens submitted to me for examination, it has only been possible to refer these altered rocks to the general group in which they belong, without assigning them to their exact position in that group.

My acknowledgments are due to Dr F. D. Adams of McGill University for valuable suggestions and assistance received from him at various times during the progress of the work.

1. FELSPATHIC ACTINOLITE SCHIST.—Louis Creek, north side, two miles up. 167 (1888). Adams Lake series. Cambrian

This, in the hand specimen, is a fine-grained, greenish-gray, schistose rock, stained with iron oxide.

Under the microscope it is seen to consist principally of felspar; a little quartz; a green mineral in long needle-like crystals possessing inclined extinction, which is probably actinolite; epidote; and chlorite.

The felspar, like the quartz, occurs in aggregates of small clear grains and is only to be distinguished from it by the axial figure. Several of these were obtained, and showed clearly the revolving bar of a biaxial figure.

The felspar and quartz grains often form, together with epidote, little clear lenticular areas in the section.

Adams Lake series—*Cont.*

The epidote is chiefly in irregular grains, occasionally in minute crystals showing sharply defined rhombic sections which are parallel to $\infty P\bar{\infty}$ and bounded by the faces oP and $P\bar{\infty}$.

2. Gabbro (?)—North Thompson River, east side, opposite mouth of Skull Creek. 193 (1890).

This rock, examined under the microscope, is seen to be much altered.

The augite originally present in it, is now almost entirely changed to hornblende, which, in its turn, is very largely altered to chlorite.

The felspar is all decomposed, and can now be traced only by outlines filled with various alteration products.

The whole section is so filled with chlorite, epidote, and sericite, that but little trace of the original structure of the rock can be seen, but it appears to have been of the nature of a gabbro, or possibly a diabase.

Dr. Dawson states that in the mass the rock is slightly schistose.

5.* Diabase Porphyrite.—Two miles east of Poison Hill. 226 (1890).

Câche Creek formation. Carboniferous

A rather coarse-grained rock, in which plagioclase and augite crystals, together with iron ore, occur porphyritically developed in a fine-grained groundmass. The rock is much altered, and the augite is nearly all converted into a fibrous, pale-green hornblende, which, in its turn, is largely altered to chlorite. The latter mineral, together with other decomposition products and fine needle-shaped individuals of hornblende, is thickly scattered through the section. The plagioclase is well twinned, often possesses good form, and is much decomposed, being filled with little granules of zoisite, epidote, etc. The groundmass of the rock, where visible, apparently possesses a holocrystalline diabasic structure.

6. Diabase porphyrite (?).—Pass between Hat Creek and Oregon Jack's Creek, one mile east of Hat Creek. 239 (1889).

The section submitted to me was so thick that a satisfactory determination was impossible.

The rock is much altered and filled with chlorite, oxides of iron, etc. Both felspar and augite are exceedingly decomposed. The former occurs in lath-shaped individuals which show the twinning characteristic of plagioclase. There is apparently considerable fine-grained groundmass present, in which minute plagioclase crystals can be distinguished, but, owing to the thickness of the section and the extreme alteration of the rock, a determination of its true character could not be made.

* There are no specimens represented by numbers 3 & 4.

Câche Creek formation—*Cont.*

7. Harzburgite (Saxonite).—As-kom' Mountain. 95 (1890).

A coarse-grained, dark-green, serpentinous rock, showing imbedded enstatite with its characteristic pearly lustre.

The only minerals observed in the sections xamined were eolivine in an advanced stage of serpentinization, an altered orthorhombic pyroxene (enstatite), and iron oxides.

For such rocks, composed essentially of olivine and enstatite, Wadsworth proposed the name *Saxonite.** Rosenbusch has used the name *Harzburgite* for the same group, and characterizes them as felspar-free olivine-norites.† The section was compared with sections of Harzburgite from Baste in the Harz and found to closely resemble them.

Dr. Dawson states that the specimen submitted to me was from one of many harder "cores" occurring in soft serpentinous schist at the locality.

It will readily be understood that as the serpentinization of the principal constituent, the olivine, proceeds, the olivine substance will eventually entirely disappear, giving rise to the soft serpentine rock in which, macroscopiçally, no trace of the original character of the rock would be perceivable.

The olivine occurs in irregular masses and shows in perfection its characteristic net-like alteration to serpentine, the strings of serpentine forming the net-work inclosing the yet unaltered portions of olivine. Hydrous iron oxides and magnetite have separated out during the process of alteration. The unaltered portion of the olivine is transparent, with marked relief, almost colourless, non-pleochroic, and exhibits brilliant interference colours.

The enstatite, like the olivine, occurs in broad, colourless, irregular masses, with parallel extinction, which are occasionally bent and twisted, and possess little or no pleochroism. It is largely altered to schiller-spar or bastite, the various stages of alteration being well shown in the sections. Some individuals exhibit merely a fine striation parallel to the vertical axis of the prism and at right angles to the partings. Others again show an alteration into a green serpentinous material, commencing in the cracks, especially those parallel to *oP*, and extending from them as threads and fibres parallel to the principal axis. The columnar structure often seen in enstatite was also observed, one individual in particular showing the long cylindrical hollows, sometimes filled with secondary ores, which are described by Rosenbusch‡ as occurring in enstatite. As he has pointed out, it is

* Lithological Studies, Cambridge, Mass., 1884.

† Massige Gesteine, 2nd Ed., 1887, pp. 269-271.

‡ Die petrographisch wichtigen Mineralien, 2nd Ed., 1885, pp. 396-397.

Câche Creek formation—*Cont.*

somewhat difficult at times to distinguish the long cavities from solid inclusions owing to the high index of refraction of the mineral which contains them. These tubular hollows are not continuous throughout the entire length of the prism. The change in the strength and character of the double refraction as the mineral changes from enstatite to bastite is most marked. In enstatite the double refraction is strong and positive, whilst in bastite it is much weaker and negative.

Only a very small specimen of this rock was available for examination, but it certainly belongs to the peridotite group and as the portion examined apparently corresponds closely to Harzburgite I have referred it to that type of the group.

8. AMPHIBOLITE.—Campbell's Creek, half a mile above Shumway Lake. 115 (1889).

The schistose structure of this rock, which consists essentially of a light-green fibrous hornblende and a triclinic felspar, is well shown under the microscope.

The hornblende occurs partly as irregular individuals elongated in the direction of the planes of foliation, and partly as small acicular crystals, having a similar general parallelism, distributed through the plagioclase. It is pleochroic in green and yellow tints, the pleochroism being more marked in the acicular crystals (actinolite?) than in the larger individuals.

The plagioclase also occurs in the same way in irregular individuals of comparatively large size, showing well-marked twinning striation, and as a fine mosaic between these larger individuals and the hornblende. That this mosaic is secondary is shown by the fact that it contains numerous minute needles of secondary hornblende.

No quartz could be determined with certainty, though a little is doubtless present.

Epidote, chlorite, iron ore, and pyrite also occur in the section, which is much stained with hydrous oxides of iron, and fine scales of a brown mica were seen in the hand specimen but were not detected in the section.

Similar schists have been shown by many observers to result from the shearing of diorites and diabases*, and it is quite likely that the rock now under consideration may have had such an origin. Teall

* See Lehmann, Untersuchungen über die Entstehung der Altkrystallinischen Schiefergesteine, Bonn, 1884, p. 190.
Gümbel, Die Palæolitischen Eruptivgesteine des Fichtelgebirges, Munich, 1874, p. 9.
G. H. Williams, Bull. U. S. Geol. Surv., No. 62, 1890.
Teall, Q.J.G.S., xli., 1893, p. 133; British Petrography, 1888, pp. 198 and 244.
Hatch, Mem. Geol. Survey, Explanation of Sheets, 138, 139, Ireland, p. 49.

points out that quartz appears to be rare in those schists which can be definitely proved to have originated in consequence of the metamorphosis of igneous rocks. Câche Creek formation—*Cont.*

(Compare Nos. 9, 10, 1, and 16).

9. AMPHIBOLITE.—Campbell Creek, one half mile below Shumway Lake. 111 (1889).

This section is almost identical in its general features with No. 8. The iron ore, however, is nearly all altered to leucoxene, which occurs in great abundance in translucent irregular forms, sometimes rudely rhombic in outline, having a granular structure and a grayish colour. The individual granules, examined with a high power, show a high index of refraction and brilliant interference colours. The section was compared with those described by Dr. Adams from the Eastern Townships of Quebec as containing a similar mineral,* and it was at once seen that the two minerals are the same, and undoubtedly leucoxene, a form of titanite or sphene derived from the alteration of titanic iron ore. Finely divided plagioclase was recognized in the groundmass.

This is another of those altered rocks which in all probability have been derived from basic igneous rocks by contact and dynamic metamorphism.

The hornblende, as in No. 8, possesses a fibrous structure and has every appearance of secondary origin.

Phillips has well described the passage from the original eruptive to similar schistose rocks, entirely devoid of the characteristics of the original rock, in occurrences at various localities in the west of England.† Teall also describes in detail the variations in structure and composition in "greenstones" from England,‡ stating that the most important secondary structural characteristics are those which depend on the development of foliation, and that the most important secondary characters in composition depend upon the development of chlorite, or some form of hornblende, at the expense of the original augite; of leucoxene, and ultimately granular sphene, or rutile, at the expense of the titaniferous iron ore; and of water-clear secondary felspar (albite ?) and other substances, at the expense of the original plagioclase.

From a perusal of the above remarks it will be seen how closely they apply to those rocks described by Dr. Adams in the report already

* Report of Progress, Geol. Surv. Can., 1880-81-82. Appendix to Dr. Selwyn's. Report, p. 16A.

† Q.J.G.S., vol. XXXII., 1876, p. 155: vol. XXXIV., 1878, p. 471.

‡ British Petrography, 1888, pp. 230, 234, 235.

Câche Creek formation—*Cont.*

referred to (see p. 353 of the present report, foot-note), and to the ones from British Columbia now under consideration.

10. Amphibolite.—Campbell Creek, one mile below Shumway Lake. 110 (1889).

This specimen is of a rather finer grain than Nos. 8 and 9, and the section shows it to contain a large quantity of a brown mica in addition to the hornblende, but its general features are the same as in those two rocks.

The groundmass, as before, consists of a fine mosaic of water-clear grains of felspar, probably albite, embedded in which are numerous little needles of actinolite, proving its secondary character. Some of the felspar grains are striated.

The hornblende occurs in irregular fibrous individuals, and also in the form of fine needle-like crystals of actinolite. It commonly shows an alteration to chlorite.

Leucoxene, in irregular bunches of fine granules with a very high index of refraction, is abundant. Quartz was not determined with certainty, as satisfactory axial figures could not be obtained.

The brown mica is very abundant in the section, being nearly equal in quantity to the hornblende with which it is intimately associated. It is reddish-brown in colour, and occurs in small irregular folia, which, in sections at right angles to the basal plane, are strongly dichroic. Its interference colours are the same as in biotite, to which species it is undoubtedly closely related, if not identical with it.

The rock is without doubt of the same origin as the similar ones already described.

11. Amphibolite.—Moore Creek, west side, four miles above Nicola Lake. 264 (1890).

This rock, whilst presenting the general features of those of the same class already described, differs from them in some respects. It is apparently less foliated, and its matrix, whilst showing the usual clear felspar mosaic, also contains numerous larger fragments of plagioclase, in some instances with crystalline form. Quartz is also present, and epidote is exceedingly abundant, in irregular, strongly pleochroic grains, exhibiting brilliant interference colours. Irregular bunches of finely granular leucoxene, accompanied by some ilmenite, are thickly scattered through the section. There are also numerous crystals of pyrite, of a good size, and showing alteration to limonite. The hornblende is decidedly uralitic in appearance and largely altered

to chlorite. In some instances forms resembling augite were seen. Only a very few small scales of brown mica are present. Câche Creek formation—*Cont.*

12. Amphibolite.—Moore Creek, west side, four miles above Nicola Lake. 265 (1890).

The rock is the same as No. 11 in its general characters, and has probably resulted from the alteration of some basic eruptive.

13. Tuff ?.—Half a mile north-west of Shumway Lake. 2A (1877).

A dark-gray, fine-grained, compact rock, which has evidently been greatly crushed and shattered. It is laminated in structure, this lamination being especially well seen on the weathered surfaces. The specimen is highly calcareous, effervescing freely with dilute hydrochloric acid, and is traversed in all directions by cracks filled with crystalline calcite.

The microscope shows the extreme alteration of the rock, which now consists of an exceedingly fine-grained mosaic of re-crystallized interlocking grains, apparently felspathic, in which are numerous clear lenticular patches and strings of quartz, which, between crossed nichols, also exhibit a mosaic structure.

Numerous little scales of a reddish-brown, strongly pleochroic biotite are scattered through the sections, which are filled with calcite in irregular patches and also filling-in the numerous cracks and partings. Scales of sericite are also abundant.

A large quantity of a black nondescript material is present, in lenticular patches and irregular strings with a general parallel arrangement, which marks out clearly the laminated structure of the rock in the thin section. Some irregular, angular patches, resembling embedded fragments, suggest that this rock may possibly be a highly altered tuff or ash-rock, but, owing to its very bad state of preservation, it is hard to arrive at any definite conclusion as to its origin.

14. Tuff ?—Half a mile north-west of Shumway Lake. 2B (1877).

A black, rusty weathering, fine-grained, thinly laminated rock, which, in thin splinters before the blowpipe, fuses readily to a brownish, glassy slag, but does not alter greatly in colour before fusion. It contains carbonates, effervescing slightly with dilute acid, but only in spots.

The remarks made regarding No. 13 apply in general to this rock, only that it is not nearly so calcareous, contains more micaceous constituents, and is more evenly laminated. The angular fragments are also more abundant and much more distinct. Large angular fragments

Câche Creek formation—*Cont.*

of felspar were observed lying across the planes of lamination, around which the other constituents bend in such a manner as to mimic "flow-structure."

Scales of a brownish micaceous mineral occur, which are frequently aggregated into rosettes throughout the rock.

As in the case of No. 13 numerous little granulated areas of quartz were observed.

15. Clastic Rock (Tuff?).—North of Douglas Lake granite mass. 342 (1877).

A fine-grained, thinly laminated, dark-gray, almost black, rusty weathering rock, in which the planes of bedding, indicated by layers of different coloured materials, are inclined at an angle of about 65° to the planes of lamination. The microscope shows it to be made up of layers of light and dark material, very finely granular, and mainly felspathic, showing evidences of partial re-crystallization, and containing many small angular fragments of felspar and quartz, scales of sericite, grains of calcite, and a large quantity of a strongly pleochroic brown mica, probably secondary, the folia of which have a general parallel arrangement corresponding to the planes of lamination in the rock.

The whole section is much stained by hydrous oxides of iron, often aggregated into patches of considerable size.

The light-coloured layers in the rock contain what appear to be composite fragments of some foliated clastic rock, the foliation of these being often at a considerable angle to that of the main mass of the rock.

16. Chloritic and Epidotic Schist.—Cayoosh Creek, near Bonanza Mine. 278 (1889).

The matrix is very fine-grained, consisting of quartz and felspar, through which the chlorite and sericite run in long, continuous, irregular folia. Epidote is very abundant in irregular granules, possessing marked pleochroism, yellow to colourless, and brilliant interference colours. Numerous little lenticular patches and bands occur throughout the section, which are chiefly composed of a hydro-mica (sericite?), with irregular crushed fragments of quartz and felspar, showing very uneven extinction, embedded in it. These fragments are larger than those in the main mass of the section.

The micaceous constituents of the rock show a well-defined parallelism.

17. Porphyroid (schistose).—Between Seton Lake and Cayoosh Creek. 276 (1889).

This consists of an exceedingly fine-grained felsite-like groundmass with a schistose structure, composed of quartz, orthoclase, and plagioclase,

Câche Creek formation—*Cont.*

much sericitic and chloritic material, and also large quantities of a black, opaque, decomposition product, which marks out clearly the lines of wavy foliation in the rock.

Much hydrous oxide of iron is also present, giving a rusty stain to the rock. Occasional larger grains of quartz and felspar are to be seen, and the section is traversed by numerous little veins of quartz.

The planes of schistosity are very wavy and contorted, and the specimen resembles the class of rocks to which the name *porphyroid* has been given, and which were first described from Thuringia, the Harz, the Taunus, and the Ardennes, where they occur associated with Palæozoic strata. They may be characterized as rocks composed of a felsite-like groundmass which has assumed a more or less schistose structure from the development of micaceous (sericitic) scales, and which contain porphyritically scattered crystals of felspar and quartz. As pointed out by Teall,* many of them are distinguished from the porphyries merely by the presence of wavy planes occupied by sericite or some other micaceous mineral, and that by an increase in the number of these planes, and a corresponding increase in the micaceous mineral, they pass into schistose porphyroids, and finally into sericite schists. They shade into hälleflinta-like rocks by the disappearance of the porphyritic constituents and of the schistose structure.

He points out that the typical porphyroids of the Ardennes bear the same relation to quartz porphyries that the "schistose greenstones" do to dolerites, and are for the most part acid rocks that have been affected by dynamic metamorphism.

18. Saussuritic Rock.—Cayoosh Creek, near Bonanza Mine. 277 (1889).

The hand specimen is a light-green, tough, compact, and somewhat schistose rock. Under the microscope the section presents the appearance of a confused felted aggregate of chlorite, zoisite, epidote, calcite, a pale green mineral in needle-like crystals resembling actinolite, and occasional patches of more or less altered felspar. Little bands filled with epidote and zoisite grains, and scales of sericite, run through the main mass. It is probably the result of metamorphism of the basic felspar of a gabbro or diabase, a change common in rocks affected by regional metamorphism.†

The name *saussurite* was originally applied by De Saussure to a similar aggregate occurring in the rock named *euphotide* by Haüy. De Saussure

* British Petrography, 1888, pp. 294, 337, 338.

† See Rosenbusch, Massige Gesteine, 2nd Ed., 1887, pp. 163-164; also Hagge, Mikroskopische Untersuchungen über Gabbro, etc., Kiel, 1871, p. 51.

Câche Creek formation—*Cont.*

believed the substance to be a definite mineral, but subsequent investigation proved its composite character.* Cathrein thoroughly investigated the substance chemically and microscopically, and his conclusions, summed up by Teall, are:—that it is not a mineral, but a mixture, as above; that in its chemical composition it, in general, resembles the soda lime felspars; that it is produced by the metamorphism of the felspar through interchange of silica and alkalies, with lime, iron, and water; and that epidote is produced in a similar manner to the zoisite, only that more iron is taken up.†

In the specimen examined the zoisite occurs in irregular grains and crystals, exhibiting its characteristic pale blue interference colours. Calcite is abundant. The few fragments of felspar observed, though much altered, show indistinctly the twinning of plagioclase.

The section being thick, but little of the matrix could be made out, but here and there a fine-grained glassy mosaic was observed, which is probably composed of felspar (albite ?).

19. Diabase Tuff.—Ridge east of Paul's Peak, near Kamloops. 102 (1889).

A rather fine-grained fragmental rock, made up of fragments of augite, plagioclase, titanic iron ore accompanied by leucoxene, hydrous iron oxides, chlorite, and fragments of what is apparently diabase porphyrite.

One of these rock fragments, though much altered, shows large, well crystallized plagioclases, a large augite crystal, and a grain of ilmenite accompanied by leucoxene, embedded in a fine-grained groundmass. Other fragments are of a much finer grain.

The augite, as a rule, is quite fresh, and often possesses sharp crystal form. Occasionally it shows alteration to a chloritic substance. It is yellowish in colour, clear, and exhibits the usual cleavages and other physical characters of the species. A few crystals were observed polysynthetically twinned according to $\infty\bar{P}\infty$. The extinction angle on the clinopinacoid in one instance was found to be 44°.

The plagioclases, like the augites, often have sharply defined crystallographic boundaries. They are greatly decomposed, and present a very cloudy appearance, the twinning structure being almost obliterated. Zonal structure was noticed in a few of them.

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* See Cathrein, Ueber Saussurit, Z.K., Band VII, 1883, p. 234; also Teall, British Petrography, 1888, pp. 148-155.

† Since the above was written Mr. A. E. Barlow has published a paper, in which the structure of Saussurite is minutely described. See On some Dykes containing Huronite, Ottawa Naturalist, vol. IX., pp. 25-47.

20. DIABASE TUFF.—Lower part of Cayoosh Creek. 285 (1889). Câche Creek formation—*Cont.*

A fine-grained, greenish-gray, somewhat schistose rock, whose clastic structure is at once seen under the microscope. It is made up of irregular fragments of plagioclase, quartz, augite, ilmenite with leucoxene, and numerous rock fragments, embedded in a fine-grained matrix filled with chlorite and epidote.

Most of the grains are plagioclase, generally much altered to calcite, kaolin, and other products of decomposition.

Some of the rock fragments referred to above, consist of broad crystals of plagioclase, with fibrous much altered hornblende, probably derived from pyroxene, and resemble gabbros; others are fine to medium-grained, with diabasic structure; whilst others again are very fine-grained and felsitic, resembling devitrified glassy eruptives. They are all much decomposed.

21. CHERT, OR CHERTY QUARTZITE.—Hills north of Medicine Creek, near Hat Creek. 259 (1889).

This is a very fine-grained, compact, siliceous rock, which, in the section examined, is cut by numerous little veins of quartz. The texture of the rock is too fine to admit of a satisfactory determination of the optical character of the separate grains or concretions of silica, but the spherulitic interference cross given by the concretions, and their general appearance, indicate that they are probably composed of chalcedonic quartz.

Dr. Dawson has pointed out *that these cherts, or cherty quartzites, have probably been produced by the action of thermal waters which silicified the accompanying rocks, and suggests that some of them may have originally been argillites.

The section examined shows many nondescript impurities, including considerable quantities of a blackish carbonaceous-looking material, and hydrous oxides of iron.

22. DIABASE PORPHYRITE.—North of Kamloops Lake, one mile and a half east of Red Point. 164 (1890). Nicola formation. Triassic.

Under the microscope this rock is seen to consist essentially of large, well defined crystals of plagioclase, augite, and iron ore, embedded in a fine-grained holocrystalline groundmass of the same materials. Epidote, calcite, pyrite, a little chlorite, and hydrous oxides of iron are also present.

* Report of Progress, Geol. Surv. Can., 1877-78, p. 92 B.

Nicola formation—*Cont.*

The rock is considerably altered. The plagioclase is cloudy and filled with decomposition products. It occurs in large, sharply-defined, well-striated individuals, and also in smaller lath-shaped crystals in the groundmass. The augite exhibits large, sharp, crystal forms, which are generally octagonal in outline and often beautifully symmetrical, both pinacoids being well developed. It is much altered to epidote, calcite, etc. The iron ore (ilmenite) is abundant and accompanied by its alteration product, leucoxene. Epidote occurs throughout the section in large quantity as the result of the decomposition of the felspar and augite. It is in the form of coarse and fine granules, and also in radiating bunches of small prisms which sometimes exhibit aggregate polarization, with a well-defined interference cross. Its pleochroism is marked, yellow to colourless. The rock is a typical diabase porphyrite.

23. Diabase Porphyrite.—Hills south of Nicola Lake. 140 (1889).

The section submitted for examination was very thick, but the rock appears to be a diabase porphyrite of the ordinary type. It is in an advanced stage of alteration, and consequently its structure, in the thin section, is much obscured by the products of decomposition.

The augite occurs in large, well defined, eight-sided sections, many of which show most beautifully its uralitization (the alteration from augite to hornblende), the central cores of the crystals consisting of unaltered augite with its characteristic cleavage, and the margins of a pale green fibrous hornblende.

Numerous radiating bundles of needle-like crystals of some zeolitic mineral occur throughout the section, probably derived from the alteration of the felspar.

Several little clear areas were noticed, which, between crossed nichols, are seen to be made up of grains of some mineral having a finely fibrous, radiated structure, and showing an interference cross. These are probably composed of chalcedonic quartz.

24. Diabase Porphyrite (amygdaloidal).—One mile south of Meadow Creek, 2½ miles above Greenstone Creek. 18 (1890).

A rather fine-grained, distinctly amygdaloidal, chocolate-brown rock, spotted with white, due to the calcite filling of the amygdules.

It consists essentially of porphyritic crystals of augite and plagioclase felspar, embedded in a fine-grained groundmass of the same materials. This groundmass is so impregnated with products of decomposition, such as hydrous iron oxides, epidote, calcite, and chlorite, as to render it impossible to determine with certainty whether glassy

matter is present or not, but the flow-structure, observable in portions of the section, would lead one to believe that it is. Nicola formation—*Cont.*

Large amygdules now filled with calcite, yellow, strongly pleochroic epidote, and zeolites, are thickly distributed through the rock. Some of these amygdules, filled as they are with radiated bunches of brilliantly polarizing epidote, are most beautiful objects under the microscope. The portions of the rock immediately surrounding the amygdules are stained a very deep brown, presumably by hydrous oxides of iron.

Alteration of the porphyritic crystals of plagioclase has proceeded to such an extent as to almost entirely obliterate their twinned structure. The porphyritic augites are also much altered to chlorite, epidote and calcite.

As seen in the section, the groundmass of the rock is made up of slender, lath-shaped sections of plagioclase, and irregular grains of augite, and possesses an apparently hypocrystalline structure, although, as above mentioned, the presence of glassy matter cannot be positively proved. A little secondary quartz was observed, and the specimen examined is traversed by numerous little cracks filled with crystalline calcite.

25. Diabase Porphyrite.—South shore of Kamloops Lake, opposite Copper Creek. 320 (1877).

A very poor section. The rock presents no unusual features. It contains a few included fragments.

26. Porphyrite.—Joshua Mine, Stump Lake. 102 (1888).

This is a soft, exceedingly decomposed, highly calcareous rock, which exhibits, in sections, a confused mass of chloritic and sericitic or talcose material, with a large quantity of carbonates.

More or less indistinct outlines of the original porphyritic felspar crystals are still visible, but now filled with calcite and other alteration products.

The large amount of carbonates in the rock renders it probable that the predominating felspar was a plagioclase. Some of these carbonates present good crystal form, showing sharply defined rhombic sections, and may be dolomite. The absorption in these crystals is marked, with O > E.

27. Melaphyre (amygdaloidal).—One-quarter mile south of Meadow Creek, $2\frac{1}{2}$ miles below Greenstone Creek. 22 (1890).

This rock, whilst resembling in a general way No. 24, is coarse-grained, and the phenocrysts of augite are larger, as are also the amygdules. Olivine is also one of its constituent minerals.

Nicola formation—*Cont.*

The amygdules, mostly rudely spherical in form, occasionally measure $\frac{3}{8}$ths of an inch in diameter and are filled with zeolites, calcite, sericite, chlorite, and epidote.

The colour of the matrix is about the same as in No. 24, namely a dark chocolate-brown.

The plagioclase phenocrysts are comparatively few in number and greatly decomposed.

Those of augite on the other hand are remarkably fresh, and occur chiefly in sharply defined, octagonal sections, which are approximately at right angles to the *c*-axis, frequently show polysynthetic twinning, a zonal structure, and contain grains of magnetite.

Numerous porphyritic skeleton crystal forms, filled with hydrous iron oxides, etc., which accompany the augites, in all probability represent a highly ferruginous olivine originally present in the rock. These ferruginous olivines (hyalosiderite, fayalite, etc.) are very characteristic of the porphyritic eruptive rocks.

28. Melaphyre. (?)—Hills south of Nicola Lake, near McDonald or Quilchenna Creek. 139 (1889).

A fine-grained, compact, dark-green rock, much fissured, and containing porphyritic crystals of augite.

The section is filled with epidote, calcite, chlorite, serpentine, and other decomposition products.

Blotches of serpentine, calcite, and iron ore, representing what was probably originally olivine, occur side by side with comparatively unaltered augite.

The plagioclase is almost entirely decomposed. Well-twinned, comparatively fresh, crystals of augite are abundant. The different states of preservation of these two minerals may be due to the composition of water acting as the decomposing agent, permitting it to act more powerfully on the plagioclase than on the augite.

A small fissure, filled with epidote, passes through the section and traverses a large augite crystal, half of which is faulted considerably to one side.

29. Gabbro, with diabasic structure. North of Kamloops Lake, one mile and a half east of Red Point. 163 (1890).

This is a considerably altered eruptive, which owes its red colour to iron oxides derived from the pyrite which is plentifully scattered through the section. The rock is composed chiefly of plagioclase, augite, epidote, and pyrite, and has somewhat the structure of a gabbro, that is, there are considerable areas of plagioclase comparatively free from

bisilicates, so that it does not possess the typical ophitic structure characteristic of a diabase. The habit of the plagioclase is also more that of gabbro plagioclases than of those occurring in diabase. Nicola formation—*Cont.*

A few porphyritic crystals of the plagioclase and augite are scattered through the section. No quartz was detected.

In a few instances what appear to be fragments of some eruptive are embedded in the mass of the rock.

30. Proterobase or Epidiorite. Road north of Trapp Lake. 120 (1889).

In the hand specimen this is a mottled green and whitish, rather coarse-grained, gneissic rock, whose foliation is not of the even type seen in a typical schist, but is more like "flaser" structure, the minerals occurring in more or less elongated streaks.

In the thin section the rock is seen to be composed chiefly of plagioclase, hornblende, augite, biotite, and a little quartz, with epidote, chlorite, titanite, apatite, pyrite, sericite, zeolites, and hydrous iron oxides, as accessory constituents.

The plagioclase occurs in the form of coarse-grained individuals, with finer crushed saussuritic material between them. The majority of them are well-striated, full of inclusions, and exhibit very uneven extinction. Twinning according to both albite and pericline laws is often seen in the same individual. The plagioclase is considerably altered, sometimes giving rise to the formation of little radiating bundles of fine needle-like crystals of some zeolitic mineral. Evidences of pressure are numerous, and the twinning lamellæ are often much bent.

The hornblende occurs in large, irregular, strongly pleochroic individuals of green and brown colours, exhibiting good cleavages; also in the form of actinolite penetrating the felspar. The same individual will often have a brown centre with an outer rim of a green colour. Although much of the hornblende has a fibrous structure, yet at first sight the greater part of it appears to be much more compact than in the case of the schistose hornblende rocks previously described, and not so uralitic in appearance. A careful examination of the section, however, shows that augite still survives in individuals which exhibit its characteristic cleavage, and it moreover forms "cores" in the hornblende, the latter mineral being clearly derived from its alteration.

A brown mica, of the variety common in altered rocks, is present in small quantity.

My interpretation of the rock is, that it is a diabase in which the original augite has been altered, and the ophitic structure almost entirely destroyed by contact and dynamic metamorphism. To such

Nicola formation—*Cont.*

rocks Gümbel applied the term *proterobase.** Some of these, and similar ones from other localities, have been shown to be normal diabases altered by the two kinds of metamorphism, contact and dynamic.†

Where the augite has entirely disappeared or is present in only very small quantities, Gümbel applied the term *epidiorite.*

It should be stated here that no sharp lines can be drawn between diabase, proterobase, and epidiorite. The transitions are gradual, and often these three types are furnished by the same rock mass. The view taken of the origin of this particular rock from its microscopical examination is borne out by Dr. Dawson's observations in the field. He regards it as a Triassic diabase which has been altered by contact with a granitic mass. Lossen has shown that the proterobase from Winzenburg, in the Harz, described by Rosenbusch as typical of that class, is a normal diabase altered by contact with granite.

31. Diabase Tuff.—Near the 232nd mile-post, Canadian Pacific Railway, south shore of Kamloops Lake. 318 (1877).

This is a rather coarse-grained clastic rock, made up of fragments and crystals of plagioclase, a pale yellowish augite, and iron ore, together with numerous fragments of what is apparently diabase porphyrite.

Much of both the plagioclase and augite show sharp crystallographic boundaries, the augite individuals being often of a large size. Both minerals are much altered, the plagioclase, as usual, more so than the augite.

The section is full of pyrite and various alteration products.

The included rock fragments show sharply defined, large crystals of augite and plagioclase, together with iron ore, porphyritically developed in a fine-grained diabasic-granular groundmass, in some instances filled with opaque decomposition products.

A large augite crystal, embedded in one of the fragments, shows in a most beautiful manner the so-called "hour-glass structure," exhibiting four fields in parallel polarized light, alternate fields displaying similar colors. The direction of maximum extinction is the same in the alternate fields, but differs in the different pairs. Subsequent filling-in of the spaces in a skeleton crystal of augite is supposed to account for

* Die paläolithischen Eruptiv-gesteine des Fichtelgebirges, Munich, 1874, p. 9.

See also Rosenbusch, Massige Gesteine 2nd ed., 1887, pp. 206-210.

† See Allport On the Metamorphic Rocks Surrounding the Land's End Mass of Granite, Q.J.G.S., 1876, XXXII., p. 407.

Lossen in Sits. d. Ges. natur. Freunde, Berlin, 1885, p, 32.

Liebe, Ubersicht über der Schichten-aufbau Ostthuringens. Abhand. Z. geo. Specialkarte v. Preussen u. d. Thüring. Staaten. Bd. V., Hft. 4.

this structure.* Zonal structure also is seen in many of the augites in the section, the zones sometimes not being parallel to the boundaries of the crystal. Nicola formation—*Cont.*

32. DIABASE TUFF.—North of Kamloops Lake, two miles and three-quarters east of Red Point, and behind Battle Bluff. 165 (1890).

This rock, under the microscope, is seen to be clastic in its origin It is composed of fragments of plagioclase felspar, augite, pyrite, zircons, etc., cemented together by a highly calcareous and ferruginous matrix which is proportionately small in quantity. Numerous fragments of tuffaceous rock are also present along with the fragments of simple minerals. In its constituent minerals it bears a close resemblance to No. 29 and is just such a tuff as one might expect to find accompanying a rock of that character.

The pyrite is very abundant, and by its oxidation has stained the rock a deep reddish-brown.

33. DIABASE TUFF.—Hills south of Nicola Lake. 138 (1889).

A dark-green, fine-grained rock, showing various irregular mineral fragments embedded in it. The section shows this to be a typical diabase tuff, holding fragments of diabase porphyrite.

This clastic rock is made up of irregular fragments of plagioclase, augite, iron ore, and the rock fragments referred to above.

Both plagioclase and augite are much decomposed, and the section has much epidote and chlorite scattered through it.

The included rock fragments possess a very fine-grained matrix, in which well defined crystals of plagioclase, augite, and iron ore are porphyritically developed.

The augite occurs in octagonal sections, is often well twinned, and in many of the fragments quite fresh, in marked contrast with the plagioclose, which is nearly always greatly decomposed.

34. DIABASE TUFF.—Peterson Creek, south of Coal Hill. 1 (1890).

A fine-grained, compact, dark-green, clastic rock, composed chiefly of irregular grains and crystals of plagioclase felspar, augite, and iron ore, together with fragments of a greatly decomposed porphyritic rock, all cemented together by finer grained material of the same kind.

The specimen is much decomposed and highly calcareous.

Both plagioclase and augite are considerably altered, the former to calcite, kaolin, etc., the latter to chlorite, epidote and magnetite.

* See L. Van Werveke in Neues Jahrbuch für Mineralogie, Geologie, und Paläontologie, Stuttgart, 1879, pp. 482 and 822.

Nicola formation—*Cont.*

35. Volcanic Breccia or Ash Rock.—One mile east of Penny's Station, Canadian Pacific Railway. A (1888).

This is a clastic rock composed of irregular fragments of felspar, augite, and iron ore, together with various more or less rounded rock fragments. The whole rock is in an advanced stage of alteration, the section being filled with the products of decomposition, such as epidote, chlorite, kaolin and hydrous iron oxides. The calcite occurs in great abundance, and the hand specimen effervesces very freely when treated with cold dilute hydrochloric acid.

The rock owes its red coloration to the abundance of iron oxides distributed through it.

The majority of the plagioclase fragments, though greatly decomposed, still show the characteristic twinning.

Although the included rock fragments show tolerably fresh, lath-shaped crystals of plagioclase, their matrix is so filled with rusty decomposition products that it is well-nigh impossible to determine what bisilicates, if any, are present. The iron ore is mainly ilmenite, which is accompanied by its alteration product leucoxene.

36. Tuffaceous Rock.—Greenstone Creek, one mile and a half below Big Fish Lake. 14 (1890).

A very fine-grained rock, dark-gray to almost black in colour.

The section examined is very thick, and the rock much decomposed, rendering it almost impossible to determine its true nature. My impression is that it is a badly decomposed, siliceous, clastic rock, probably a tuff connected with some of the eruptives of the neighbourhood. Irregular, badly shattered fragments of quartz, augite, and felspar, are embedded in a very fine-grained granular matrix of apparently the same materials, but the section is so filled with a confused mass of chloritic and sericitic material, together with calcite and iron oxides, that it is difficult to make out any traces of structure in it.

37. Diabasic Tuff.—Near Cornwall's. 247 (1889).

A dark coloured, highly calcareous rock, the clastic character of which is well seen in the hand specimen. Under the microscope it presents the appearance of a loose volcanic tuff made up of fragments of an exceedingly fine-grained, amygdaloidal, porphyritic rock, cemented together by alteration products, of which the chief is calcite.

The individual fragments resemble somewhat a pumice-stone, and before the rock was consolidated and the cavities filled up, it must have been of the nature of a very loosely coherent volcanic tuff.

Cretaceous rocks.

38. Diabase Tuff.—East side of Fraser River, about eight miles below Lillooet. 295 (1889).

A rather fine-grained, much decomposed, but distinctly clastic rock, composed of irregular grains of plagioclase, quartz, augite, ilmenite, and titanite, together with fragments of some porphyritic basic eruptive. The thin section examined is full of chlorite, epidote, secondary biotite, and hydrous iron oxides, resulting from the alteration of the constituent minerals, of which plagioclase, greatly decomposed, predominates. The augite is mainly altered to chlorite, although a few tolerably fresh grains were observed. Ilmenite is tolerably abundant and is accompanied by leucoxene. The grains of quartz are sometimes angular and sometimes rounded in outline.

Cretaceous rocks—*Cont.*

Fragments of some basic eruptive containing well-developed phenocrysts of plagioclase, and bisilicates too decomposed for satisfactory identification, are scattered through the section.

It is not always possible to determine with certainty whether a tuffaceous rock has been built up of ejected volcanic material, or has been derived from the disintegration of pre-existing eruptive masses.* Dr. Dawson informs me that this rock and the two following (Nos. 39 and 40), from the field evidence, have apparently been formed in the latter way from older diabasic rocks.

39. Diabase tuff.—Near Fountain. 316 (1889).

In appearance this rock greatly resembles No. 38, but is slightly darker in colour, and under the microscope their structure and composition is seen to be practically identical, No. 38, as represented by the section examined, holding perhaps a somewhat larger quantity of bisilicates than No. 39.

40 Diabase tuff.—Road from Ashcroft to Câche Creek, two and a half miles from Ashcroft. 120 (1890).

This is a very fine-grained, compact, dark-green, somewhat calcareous rock, which the microscope shows to be distinctly clastic in origin.

Irregular angular grains and crystals of felspar, quartz, augite, and iron ore, together with fragments of some fine-grained porphyritic rock, are cemented together by a paste of finer-grained material of the same kind, filled with calcite, chlorite, epidote, and other decomposition products.

Plagioclase is the most abundant mineral present and is much altered. A few untwinned grains of felspar were also observed.

The grains of quartz are much fractured as the result of pressure.

* See E. Reyer, Ueber Tuffe and Tuffogene Sedimente. Jahrb. K.K. Geol. Reichanst, XXXI., 1881, p. 57.

Cretaceous rocks—*Cont.*

The augite, although in a few instances fresh and exhibiting crystal form, is usually largely changed to chlorite, with separation of secondary magnetite in little granules.

The iron ore, chiefly titaniferous, is generally accompanied by its alteration product, leucoxene.

Some fragments of a badly decomposed basic porphyritic rock were noted in the section examined, which is also traversed by several little veins of calcite.

41. See page 389 B

Tertiary rocks.

42. GABBRO.—Arthur's Seat. 53 (1890).

A medium-grained, altered, greenish rock, composed principally of plagioclase felspar, augite, quartz, diallage (now almost entirely decomposed), iron ore, epidote, chlorite, serpentine, and apatite.

The rock is greatly decomposed, and in places has a coarse ophitic structure, causing it to approach the diabases.

The plagioclase is almost completely saussuritized.

Sharply defined crystals of augite occur as phenocrysts, also some forms which were perhaps once olivine. The augites are fresh, often polysynthetically twinned, and hold numerous inclusions.

The diallage is in broad laminæ, which are almost entirely altered to fibrous aggregates of pale brownish-green serpentine and chlorite, together with granules of brilliantly polarizing yellow epidote. Titanic iron ore, in some instances accompanied by leucoxene, is abundant. A little quartz is also present.

43. QUARTZLESS PORPHYRY (ORTHOPHYRE). One mile and a half north of Spence's Bridge, west side of Thompson River. 51 (1890).

A light yellowish, decomposed rock, with marked spherulitic structure, in fact nearly the whole mass of the rock is made up of spherulites averaging three-eighths of an inch in diameter. The groundmass of the rock is a holocrystalline fine-grained mosaic of unstriated felspar and quartz, both possessing very uneven extinction.

In this groundmass are embedded broad, irregular, kaolinized, felspar individuals. Most of the felspar in the rock occurs, however, in the form of exceedingly slender microlitic crystals, radially grouped, and forming complete star-like spherulites of felspar, which are often outlined by borders of limonite or some similar hydrous oxide of iron.

Pyrite cubes largely altered to limonite, and irregular blotches of the latter mineral, are plentiful, and the whole rock is stained a yellowish-brown from this cause.

Carbonates also occur, and there are several little cracks, filled with chalcedonic quartz, running through the section. Tertiary rocks —*Cont.*

44. Mica Porphyrite.* Two miles south-east of Ashcroft. 249 (1889).

A light greenish, medium-grained, porphyritic rock, in which large glassy phenocrysts of plagioclase felspar, with a most beautiful zonal structure, occur, together with a dark-brown strongly pleochroic biotite and numerous grains and crystals of magnetite, embedded in a very fine-grained groundmass composed of plagioclase, little scales of biotite, and granules of iron ore, together with, apparently, a little glassy matter.

The plagioclase phenocrysts are often in the form of two polysynthetically twinned individuals united according to the Carlsbad law.

The biotite individuals bear evidence of magmatic resorption in their corroded outlines, and frequently hold inclusions of the magnetite. A little apatite is present, but no quartz was detected in the section examined.

45. Mica Porphyrite.—Nicola River, three miles below Spioos River. 152 (1889).

This is essentially the same rock as No. 46, but the section, under the microscope, shows the porphyritic constituents to be more abundant, and also that a considerable quantity of a dark green hornblende is present amongst them. The groundmass, too, presents a different appearance, the felspar individuals being stouter and the "flow-structure" not nearly so marked a feature of the rock. Zonal structure is beautifully exhibited in many of the plagioclase individuals.

Evidences of magmatic resorption are numerous, especially in the case of the hornblende, the individuals of which have often more than half disappeared, the remaining portion being surrounded by a rim of little granules of magnetite. The hornblende occurs in prismatic individuals, which occasionally, where resorption has not proceeded too far, show good terminations. It possesses strong pleochroism in brownish-green to yellow tints. The biotite frequently exhibits sharp hexagonal outlines. Apatite and iron ore are tolerably abundant.

46. Mica Porphyrite.—Three miles east, up gully, from No. 45. 153 (1889).

This, in the hand specimen, is a very fine-grained, light grayish-white, porphyritic rock, somewhat stained with hydrous oxide of iron.

* Nos. 44, 45 and 46 were described when I was unaware of their geological position. They would correspond to the andesites of Rosenbusch, as in his classification the distinction between the two is based on their age, the porphyrites are pre-Tertiary andesites. Teall uses the term mica porphyrite for altered mica andesites.

Tertiary rocks —*Cont.*

Under the microscope it is seen to consist of a fine-grained, apparently holocrystallines, groundmass, composed chiefly of small, slender, lath-shaped sections of plagioclase, together with numerous fine scales of a dark brown mica, hematite, small granules of iron ore, and carbonates.

In this groundmass, crystals of glassy plagioclase and a dark brown mica are porphyritically developed. The rock possesses a well-marked "flow-structure," the little plagioclases having a general parallel arrangement, and bending around the larger felspar crystals like logs floating in a stream. The porphyritic felspars have good crystal outlines, are mostly tabular in habit, and exhibit both binary and polysynthetic twinning. Zonal structure, though observed, is not frequent. They contain numerous microlites, and cavities filled with fluid containing bubbles, and often exhibit alteration to kaolin and calcite. The mica, probably biotite, occurs in deep brown coloured individuals with marked absorption, and occasionally possess sharp hexagonal outlines. In sections at right angles to the base, a bending of the laminæ is often seen, and the individuals sometimes show corrosion on the edges, and are filled with minute inclusions, principally granules of iron ore.

Occasional sharply defined hexagonal forms of an opaque black substance resembling iron ore were observed in this section. These have been seen and described, in the case of porphyrites from various foreign localities, as being due to the magmatic resorption of the original biotite, which has been entirely replaced by magnetite.*

47. Diabase Porphyrite.—Arthur's Seat. 184 (1889).

A light green, fine-grained, porphyritic rock, in which the microscope reveals a diabasic crystalline groundmass, made up of lath-shaped sections of plagioclase and irregular grains of augite. Through this groundmass are scattered numerous phenocrysts of augite and plagioclase. Irregular granules of iron ore are sprinkled through the section, which also contains much epidote, and chloritic material exhibiting spherulitic structure with the usual revolving black crosses when viewed between crossed nichols.

The felspar phenocrysts are much altered, and in many cases show no twinning striation. Occasionally several irregular shaped individuals are bunched together, forming "eyes."

The augite is remarkably fresh, usually exhibits good crystal outlines, and occurs sometimes in isolated individuals, sometimes in polysomatic groups resembling those described by Lawson in dykes from

*Cf. Rosenbusch, Massige Gesteine, 2nd edition, 1887, p. 452.

Rainy Lake, Ontario.* In colour it varies from pale-yellow to almost colourless, is frequently polysynthetically twinned, and possesses little or no pleochroism.

Tertiary rocks —*Cont.*

48. DIABASE PORPHYRITE?—Overlying the massive rocks of Battle Bluff, near Tranquille. 204 (1888).

In the hand specimen this is a greenish-gray, fine-grained rock, much decomposed, and finely pitted on weathered surfaces, owing to the removal of the porphyritic constituents.

Under the miscroscope the groundmass is seen to be exceedingly decomposed, with an apparently diabasic-granular structure, and composed of plagioclase and augite, with some quartz.

That the rock has been squeezed, is seen in the breaking and uneven extinction of the felspars. The phenocrysts consist of plagioclase and augite. The whole section is filled with epidote, sometimes radially arranged, chlorite, and irregular granules of iron ore.

49. AUGITE PORPHYRITE?—Skoon-ko′ Creek, below Arthur's Seat. 185 (1889).

A light greenish, fine-grained, porphyritic rock, consisting chiefly of phenocrysts of plagioclase and augite in a fine-grained groundmass composed of slender lath-shaped sections of plagioclase, some quartz, and grains of augite and iron ore.

The porphyritic augite occurs in well-formed, light green, isolated individuals, generally of short prismatic habit, but also in polysomatic groups. Sometimes these crystals have a central portion consisting of brown hornblende with characteristic cleavages, and a few isolated individuals of this latter mineral also occur. Alteration to chlorite, epidote, and carbonates, is common.

The phenocrysts of plagioclase are much altered, with formation of epidote, hydromicas, &c. A little apatite was observed. Epidote is exceedingly abundant in the rock, as may be readily seen by an examination of the hand specimen.

The uneven extinction of the constituent minerals of this rock is one of its most marked features, indicating that it has been subjected to considerable pressure.

50. AUGITE PORPHYRITE?—Skoon-ko′ Creek, three miles east of Bo′tanie Lake. 207 (1889).

This rock is rather fine-grained in texture and has an amygdaloidal structure, the amygdules showing, under the microscope, a filling of

*Annual Report, Geol. Surv. Can., vol. III (N.S.), part I., 1887-88, p. 161 F.

Tertiary rocks —*Cont.*

chlorite which polarizes in the usual characteristic indigo tints and is arranged in rosettes, this structure somewhat concealing the weak double refraction of the mineral. Occasionally there is an outer rim of secondary quartz in these amygdules. In ordinary light the sections of the amydules appear filled with a light green chlorite, and sometimes have an outer rim of colourless, transparent quartz.

Slender lath-shaped sections of plagioclase occur in the groundmass, arranged in such a manner as to give a "flow-structure" to the rock.

Phenocrysts of augite, now largely replaced by chlorite polarizing in deep blue tints, hydrous oxides of iron, and carbonates, are present. Granules of iron ore are abundant. The whole rock is much decomposed and highly calcareous, the thin section showing calcite to be abundant, and the hand specimen effervescing freely with dilute hydrochloric acid.

51. Augite Porphyrite.—Arthur's Seat. 53A (1890).

A dark grayish-green, compact, porphyritic rock, whose structure, under the microscope, approaches more closely to the augite porphyrites proper, than to the diabase porphyrite division of the general augite porphyrite group.

The groundmass does not possess the typical ophitic or diabasic structure seen in other similar rocks described in this report, but is fine-grained and apparently hypocrystalline, although the actual presence of glassy matter could not be satisfactorily proved, owing to the numerous alteration products and particles of iron ore present, and the thickness of the section examined.*

The porphyritic crystals of plagioclase are, as a rule, quite fresh and well twinned, the general form of the sections being lath-shaped. They are comparatively isolated in the groundmass, and often, by their parallel arrangement, give to the rock a rude "flow-structure."

The augite phenocrysts are large, and usually quite fresh, although many examples of more or less complete alteration to chloritic and serpentinous material, with separation of secondary magnetite, were observed. In colour, they are, when fresh, light yellowish-green to almost colourless. Polysomatic structure was frequently seen; polysynthetic twinning and zonal structure are also of common occurrence. They show uneven extinction, and hold numerous inclusions of apatite, magnetite, and fluid lacunæ.

Particles of magnetite are sprinkled throughout the groundmass.

* The rocks named augite porphyrites are for the most part greatly decomposed, and were described without reference to their geological position. They differ from the fresh glassy rocks of the Upper Volcanic Series, and I prefer in the meantime, to retain this term for them. Rosenbusch confines the name to pre-Tertiary rocks.

Some quartz occurs in the section, which, as the whole rock is greatly altered, is probably secondary in its origin. Tertiary rocks —Cont.

52. Augite Porphyrite. Murray Mountain (summit). 224 (1889).

A rather fine-grained, dark yellowish-green, porphyritic rock. In thin sections it appears to be tolerably fresh, consisting of large phenocrysts of plagioclase and augite in a fine-grained groundmass which is apparently composed of the same materials, together with numerous granules of iron ore and a little glassy base.

Some crystals of what appears to be an orthorhombic pyroxene, now largely altered to serpentine, also occur in elongated narrow forms, as well as in smaller, stouter ones. It possesses marked pleochroism.

The plagioclase phenocrysts are tolerably fresh, full of inclusions, well striated, and possess good zonal structure. A determination of the angle of extinction in one instance showed the crystal to be labradorite. Penetration twins are common.

The augite phenocrysts have well-defined crystal form, are quite fresh, often twinned, and occur frequently in groups. Their colour is a pale yellowish-green; they show brilliant polarization colours and hold numerous inclusions. A little apatite was observed in the rock.

53. Augite Porphyrite?—Cairn Mountain. 231 (1889).

A rather fine-grained, brownish-green, rusty weathering, porphyritic rock, the hand specimen of which somewhat resembles No. 52. Plagioclase phenocrysts are abundant and tolerably fresh, but the bisilicates have been almost entirely decomposed. The quantity of iron oxides separated out in the decomposed material in the section gives one the impression that the principal bisilicate present was augite, and the rock might therefore be classed with the augite porphyrites.

54. Augite Porphyrite.—Za-kwaski Mountain. 160 (1889)

A fine-grained, brownish-gray, rusty weathering rock, with very small porphyritic crystals of plagioclase and augite.

Under the microscope the augite individuals in many instances show polysynthetic twinning according to $\infty P\infty$. Most of the sections are parallel to the principal axis; a few at right angles to it. Some of the crystals have an outer shell which does not extinguish with the inner portion of the crystal, this zonal structure being sometimes very marked. Flow-structure is beautifully developed in the thin section examined.

Iron ore, probably magnetite, is very abundant in small grains, and a brown decomposition product is spread throughout the mass of the

Tertiary rocks —*Cont.*

rock, giving a brownish tinge to the hand specimen on a freshly fractured surface.

Numerous "nests" of granular augite, epidote, magnetite, etc., occur, some of which, by their form, seem to indicate a replacement of some porphyritic bisilicate constituent.

The plagioclase phenocrysts are not nearly so abundant as those of augite. A very little quartz is present.

55. Augite Porphyrite.—Nicola River, south side, two miles above Skuh'-un Creek. 168 (1889).

A fine-grained groundmass, apparently largely made up of slender little plagioclase crystals, with abundant brownish oxides of iron and chloritic material. Throughout this groundmass are scattered numerous porphyritic crystals and grains of felspar, augite, and iron ore.

The felspar is chiefly plagioclase, but some untwinned grains occur which may possibly be orthoclase, in which case the rock would approach the syenite porphyries in composition. Some of the felspar individuals exhibit only binary twinning and all show good crystal form. The striated felspar frequently exhibits an alteration to calcite.

The augite is light green to almost colourless, very faintly pleochroic, polarizes in brilliant tints, and often exhibits more or less complete alteration to a light green chloritic material.

56. Augite Porphyrite?—Three miles up Pimainus Creek. 183 (1889).

A very dark green, compact, fine-grained, porphyritic rock; the phenocrysts of felspar being of a yellowish-white colour and showing up in marked contrast with the dark groundmass of the rock. The thin section shows this rock to be exceedingly decomposed and sheared, many of the shearing planes being marked by a deposition of felspathic and quartzose material.

The groundmass consists of a confused aggregate of decomposition products, chiefly chlorite, carbonates, iron oxides, and pyrite.

The felspar phenocrysts, though in an advanced stage of alteration to saussurite, calcite, etc., still show the characteristic twinning of plagioclase in many instances.

Numerous skeleton forms, some of them octagonal in outline and now filled with chlorite, secondary quartz, and other materials, probably represent the augite originally present in the rock. Pyrite is very abundant in the section, and numerous small prisms of apatite were also observed.

What little structure can still be made out leads me to refer the rock, somewhat doubtfully, to the augite porphyrites. Tertiary rocks —*Cont.*

57. Augite Porphyrite.—Copper Creek Valley, east side, ½ mile back from Kamloops Lake. 199 (1888).

A greenish, much decomposed, highly calcareous, medium-grained, porphyritic rock, the matrix of which is of a darker shade of green than the porphyritic crystals.

In a thin section, under the microscope, the rock is seen to have suffered extreme alteration to saussuritic, chloritic, and other decomposition products. It is full of pyrite, and stained throughout with hydrous oxides of iron. Its alteration, however, has but little affected the sharpness of outline of its porphyritic constituents, which, although their original substance has now almost entirely disappeared, were clearly plagioclase and augite. Iron ore was also abundant.

Small lath-shaped sections of plagioclase can still be seen in the matrix, but whether glassy matter is present or not could not be satisfactorily determined.

The rock can, without doubt, be referred to the group of augite porphyrites, but it is hardly possible to refer it with certainty to its exact place in that group, owing to its extreme alteration.

58. Porphyrite?—Hill near Murray Mountain. 218 (1889).

The rock, in the hand specimen, is much decomposed, of a light-gray colour, mottled with whitish crystals of altered felspar. It is fine-grained and porous in texture. On examination it proved to be so completely decomposed that a determination of its true character would be a matter of much difficulty, unless fresh material could be obtained.

Porphyritic crystals of plagioclase, almost entirely replaced by saussuritic material, and carbonates, occur in a groundmass equally decomposed, and apparently made up of slender little plagioclase laths with epidote, chlorite, iron ore, and patches of crystalline carbonates.

Portions of the rock show an indistinct "flow-structure." The original bisilicates have now entirely disappeared, their places being taken by the chlorite, epidote and other products of decomposition already mentioned.

59. Porphyrite.—Mī-mēm'ooh, Nicoamen Plateau. 164 (1889).

A light greenish-gray, fine-grained, porphyritic rock, exceedingly decomposed. Porphyritic crystals of plagioclase with well-marked zonal structure, twinned according to both albite and pericline laws, and showing alteration to calcite, are plentifully distributed through an apparently holocrystalline groundmass consisting chiefly of plagioclase.

Tertiary rocks —*Cont.*

In addition to the porphyritic plagioclases, many elongated forms occur which represent the original bisilicates of the rock. They are now chiefly filled with magnetite and chlorite, and, from their general appearance, were probably hornblende, although biotite may also have originally been present. They bear every evidence of having been subjected to magmatic resorption. Iron ore is quite plentiful in the section.

60. PORPHYRITE.—North side of Nicola River, four miles and three-quarters above Skuh'-un Creek. 171 (1889).

A fine-grained, greenish and deep red, compact rock. Alteration is seen, by an examination of the section, to have proceeded to such an extent as to almost entirely mask the original structure of the rock.

A few scattered porphyritic crystals of felspar, apparently plagioclase, occur in the fine-grained groundmass, and numerous patches of reddish-brown to black decomposition products, some of which have cores of bright light-green serpentinous material, probably represent the original bisilicates of the rock. The serpentine exhibits a fibrous spherulitic structure with aggregate polarization.

61. PORPHYRITE.—Nicola River, four miles above Skuh'-un Creek south side. 170 (1889).

A fine-grained, dark brownish rock, with numerous small, yellowish, white, porphyritic felspar crystals.

It is exceedingly decomposed, and consists of a very fine-grained groundmass, full of carbonates, chlorite, and other decomposition products, through which are distributed numerous porphyritic individuals of felspar, most of which, when not too much altered, show the polysynthetic twinning of plagioclase. The majority of the individuals, however, show more or less complete alteration to a grayish saussuritic material.

In addition to the felspar, a number of forms occur, now filled almost entirely with decomposition products, which were originally either augite or hornblende. Magnetite and brown or reddish oxides of iron are abundant.

A few of the highly altered forms above referred to, show small comparatively unaltered cores, which possess the cleavage of augite, and the rock may possibly be a much altered augite porphyrite.

62. PORPHYRITE (AUGITE PORPHYRITE?).—South side Nicola River, one mile and a half above Skuh'-un Creek. 176 (1889).

A much altered, light greenish, medium-grained, porphyritic rock.

Tertiary rocks —*Cont.*

Numerous phenocrysts of plagioclase and augite, both much decomposed, are embedded in a very fine-grained diabasic groundmass composed of sections of plagioclase, grains of augite, and granules of magnetite. The augite shows very uneven extinction.

The whole section is so filled with the products of decomposition that it is difficult to say whether glassy matter is present or not.

63. Olivine Basalt.—East end of Porcupine Ridge. 234 (1890).

A dark-gray, almost black, fine-grained, porphyritic rock, in which plagioclase, olivine, and biotite are porphyritically developed in a fine-grained groundmass of the same materials, thickly sprinkled with granules of iron ore, and containing some augite, together with a certain amount of glassy matter.

The plagioclase phenocrysts are clear and glassy, polysynthetically twinned, usually in long lath-shaped sections, but occasionally in stouter forms. They frequently show corroded outlines, and hold inclusions of the general groundmass of the rock. Plagioclase is also abundant in fine microlitic crystals in the groundmass.

The olivine is mostly in irregular individuals, rarely showing crystal outlines, and exhibits its characteristic alteration to a brownish serpentine, although many of the grains are remarkably fresh, and polarize brilliantly.

The biotite is in irregular scales, which are strongly pleochroic, from deep reddish-brown to pale yellow. The augite is not very abundant, and occurs as small, irregular, pale yellowish or greenish grains.

64. Hornblende Andesite.—Porcupine Ridge, slope north of Tranquille Lake. 236 (1890).

A dark greenish-gray laminated rock, with a vitreous lustre, holding large phenocrysts of plagioclase.

The groundmass is composed of long, slender plagioclases, with a marked parallel arrangement, so thickly crowded together that but little interstitial glassy matter can be seen. In fact, the structure is almost entirely holocrystalline, but the parallel arrangement of the plagioclases, and the manner in which they bend around the porphyritic constituents, give a most typical "flow-structure" to the rock.

Distributed through this groundmass are numerous phenocrysts of plagioclase, hornblende, and augite, with magnetite, and a little apatite. Olivine and titanite occur as accessory constituents.

The plagioclase phenocrysts are mostly broadly tabular in habit, and frequently over $\frac{1}{2}$ inch long. They frequently form complicated groups of interpenetrating crystals, which sometimes form Carlsbad twins, in

Tertiary rocks —*Cont.*

addition to the ordinary polysynthetic twinning. They are much altered, and hold numerous inclusions of hornblende, augite, magnetite, etc. It is possible that a few clear non-striated Carlsbad twins observed, may be sanidine. Evidences of pressure are seen in the uneven extinction and breaking of felspars, hornblende, and augite.

The hornblende forms sometimes idiomorphic, sometimes irregular, strongly pleochroic individuals of a green colour, containing many inclusions, and frequently showing alteration to chlorite.

Augite of pale greenish or yellowish tints, sometimes with crystal outlines, more often without, is not so common as the hornblende. A few individuals of what may be an orthorhombic pyroxene, much altered, were also observed. Olivine occurs in irregular grains with characteristic double refraction and alteration to serpentine.

The magnetite frequently forms large individuals with good crystal outlines, around some of which the little felspar laths of the groundmass bend in a most remarkable manner.

A few small crystals of titanite and apatite were observed.

65. Picrite Porphyrite.—Barnes Creek Valley, north side, four miles east of Barnes Lake. 47 (1889).

A very dark green, fine-grained, compact, porphyritic rock.

Phenocrysts of olivine, and a few of augite, occur in a groundmass made up of plagioclase, augite, and glassy material.

A section of the rock was etched with hydrochloric acid and stained with fuchsine, and it was found that at least nine-tenths of the phenocrysts are olivine. A very few of augite also occur which greatly resemble the olivines.

The rock is exceedingly basic in composition and, consequently, there are no plagioclase phenocrysts, all of that mineral being in the groundmass.

66. Picrite Porphyrite.—Near Watching Creek, north of Pass Lake. 245 (1890).

A dark greenish-gray rock, thickly mottled with dark brown spots representing some altered porphyritic constituent. On examining thin sections of the rock it proves to be in a very advanced stage of decomposition. Numerous skeleton forms, sometimes possessing rude crystal outlines, but often of very irregular shape and surrounded by dark rims of iron ore, are scattered thickly through the groundmass. They apparently represent phenocrysts of olivine originally present, but now replaced by serpentine, and in some instances by a colourless substance

with weak double-refraction, which appears to correspond in character with pseudophite.* Occasionally the filling consists of an isotropic substance which is probably glass. These forms are numerous, of large size, up to one-eighth inch or more, and are much fractured, the broken pieces being sometimes quite widely separated. Tertiary rocks —Cont.

The groundmass is a confused aggregate of glassy matter, holding numerous granules and little crystals of augite, a little quartz and felspar, and iron ore in small granules. The glass is full of trichites, globulites, and other inclusions. A few forms, which may have been plagioclase, were observed, and it is probable that a little basic plagioclase was originally present, from which the pseudophitic alteration product might be derived. Clear, rounded areas, with spherulitic structure, containing chlorite, etc., which are probably partly devitrified glass, occur in the groundmass.

This rock, in spite of its poor state of preservation, is a most interesting one and should well repay further study.

67. AUGITE PICRITE PORPHYRITE.—West side of Copper Creek Valley, one mile and a half back from Kamloops Lake. 197 (1888).

A dark-green, medium-grained rock ; pitted on weathered surfaces, and showing clearly the reddish, weathered-out, olivine.

An examination of the section shows that the porphyritic constituents make up fully two-thirds of the mass of the rock.

Olivine, augite, iron ore, serpentine, chlorite, epidote, and leucoxene, are the principal minerals present in the section. It is so filled with serpentinous and chloritic material, derived from the alteration of the olivine, as to make it very difficult to determine whether glassy matter exists or not ; but it is probably present in the rock.

The olivine is the most abundant constituent, and occurs in large rounded phenocrysts which show in a most beautiful and remarkable manner the usual alteration to serpentine. The centres of the crystals are in most cases composed of quite fresh, colourless, olivine, possessing the usual high index of refraction, brilliant polarization colours, and other characters pertaining to that mineral.

Granules of iron ore, separated out during the process of alteration, are plentifully sprinkled throughout the crystals.

The augite occurs in well-defined yellowish crystals, occasionally twinned, with characteristic cleavage and well-marked zonal structure. They are, as a rule, much fresher than the olivines, and often occur in groups of sharp crystals.

*Cf. Kenngott, Ber. Ak. Wien, 16, 1885.

Tertiary rocks —*Cont.*

Iron ore, probably mostly magnetite, although ilmenite also occurs, is very abundant in irregular grains and crystals.

The groundmass of the rock consists of a confused mass of serpentinous and chloritic material, with numerous little granules and minute crystals of augite and epidote, often collected in the form of rims around the olivine and augite phenocrysts. Glassy matter is apparently present, but, as stated above, it is difficult to identify it with certainty.

68. Mica Trachyte.—Savona Mountain. 147 (1890).

A pale grayish, compact, fine-grained, cellular rock; in which occur numerous minute porphyritic crystals of a glassy felspar and a dark-coloured mica. It possesses a well marked "flow-structure." In the thin section the rock is seen to consist of a fine-grained, hypocrystalline groundmass, through which are distributed numerous porphyritic crystals of sanidine, plagioclase, biotite, and acmite or ægirine. Apatite is also present.

The rock is therefore to be regarded as an intermediate form between the mica trachytes and the andesites, but is more closely related to the former.

The sanidine is in quite fresh, tabular, glassy, well formed, much cracked, idiomorphic crystals, inclosing microlites, some of which at least may be referred to augite. The sanidines possess good cleavage as a rule, and occasionally hold, in addition to the microlites, larger inclusions of the biotite, augite, and other constituents of the rock. On the whole, however, the crystals are tolerably free from foreign matter. The sections are sometimes broad and tabular, sometimes narrow and columnar. Those parallel to $\infty \grave{\mathrm{I}}$, bounded by oP, ∞P, $\infty \bar{P} \infty$ are common. In one example the angle $oP \wedge \infty \grave{P} \infty$ was measured, and gave 105°. Rectangular sections at right angles to oP. $\infty \grave{P} \infty$, also occur. The outlines are occasionally rounded or irregular owing to magmatic resorption, and the crystals frequently show little bays running into them, filled with the material of the groundmass. Sometimes several individuals of irregular shape are clustered together, forming the so-called "sanidine eyes." The crystals are often bent and broken, and twinning according to the Carlsbad law, with very irregular boundaries between the two halves of the crystal, is common.

Zonal structure is beautifully developed in some cases, the extinction varying in the different layers of the crystal.

A few felspar crystals possessing a fine microcline-like structure and undulatory extinction were observed, which may possibly be anorthoclase.

69. DACITE.—Twaal Creek, five miles and a half above its mouth. 41 (1890). Tertiary rocks—*Cont.*

This is a coarse-grained, light yellowish-gray rock, with numerous large porphyritic crystals of quartz and plagioclase distributed through it.

It is remarkably free from coloured bisilicates ; a few little patches of chlorite and epidote, stained with iron ore, probably representing those originally present.

Large, much fractured, phenocrysts of quartz and plagioclase occur in a fine-grained granular groundmass, composed of quartz and felspar, with numerous little patches of calcite.

A little unstriated glassy felspar is present, which may be sanidine.

Pyrite crystals are thickly scattered through the section, and apatite, in rather large, well-developed crystals, is also plentiful.

The plagioclase phenocrysts are tabular in form and have the *microtine* habit, that is, are glassy and colourless, resembling sanidine. They are much altered to calcite, epidote, and a greenish pseudophitic substance, similar to that which has been noted by Rosenbusch as a decomposition product of plagioclase in andesites from Kapnik and Stenzelberg in the Siebengebirge.* The average of six determinations of the extinction angle on M gave 22° 30′, which brings it in the labradorite series of the plagioclase felspars.

The felspar of the groundmass is mainly allotriomorphic in habit, and, like the phenocrysts, is much decomposed.

The quartz phenocrysts are rounded in outline, and occasionally measure as much as half an inch in length. A close examination of the specimen reveals the fact that many of them are really doubly terminated prisms, whose edges and angles have been greatly rounded owing to magmatic resorption. They are much cracked, broken, and displaced, and are full of inclusions, such as minute colourless microlites and inclosures of the groundmass, also confused aggregates of chloritic and epidotic material, with some pyrite. Little bays run into the quartz, filled with the groundmass material.

The quartz of the groundmass has the same appearance as that usually seen in the micrograniticquartz porphyries.

70. DACITE, PASSING INTO A LIPARITE.—Upper Tranquille River. 353 (1889).

A very light pinkish-gray, fine-grained, compact, fresh looking, porphyritic rock, composed chiefly of plagioclase, an unstriated felspar

* Massige Gesteine, 2nd Ed., Stuttgart, 1887, p. 656.

Tertiary rocks —*Cont.*

(sanidine ?), quartz, and biotite individuals, porphyritically developed in a microcrystalline groundmass.

The occurrence of a considerable quantity of unstriated felspar along with the plagioclase shows that the rock is to be regarded as a transition form between the dacites and liparites.

The quartz occurs in much cracked, rounded individuals, frequently inclosing portions of the groundmass.

Both the plagioclase and sanidine are fresh and glassy, the former well-striated, and the latter frequently occurring in large binary twins. Their outlines are much rounded, as in the case of the quartz.

The biotite, of a deep brown colour, occurs in well-formed six-sided crystals and irregular plates, which exhibit strong pleochroism and polarize in brilliant tints. Inclusions of iron ore and apatite are frequent. Little microlites of augite occur in the groundmass of the rock, through which granules of iron ore are also plentifully scattered.

71. Mica Andesite.—Trachyte Hills. 260 (1889).

A chalky, fine-grained, light cream-coloured, porphyritic, rusty weathering rock, which, examined under the microscope, exhibits porphyritic crystals of plagioclase and biotite, developed in a fine-grained groundmass composed chiefly of plagioclase, with a little iron ore.

The plagioclase phenocrysts are comparatively few in number, have a glassy and colourless habit, and well developed fine zonal structure. In form they are mostly tabular, the sections being rectangular or short oblong, occasionally prismatic. Binary twinning according to the Carlsbad law is common. The twinning lamallæ are not numerous in the individuals, and in one instance apparently entirely absent. In such a case it is hardly possible, without a chemical test, to assert that the individual is a plagioclase and not sanidine. A determination of the angles of extinction seems to show that most of the felspar is to be referred to the oligoclase and albite divisions. The crystals often have an uneven extinction, are cracked, and hold numerous inclusions of glassy material, prisms of apatite, granules of iron ore, and little scales of biotite. Evidences of corrosion are numerous, the sections having the angles much rounded, and numerous little bays, filled with the materials of the groundmass, running into them from all sides. A pseudophitic alteration product is developed in some instances along the cracks which traverse the crystals.

The felspar of the groundmass consists of small lath-shaped sections of plagioclase of greatly varying dimensions, mostly in the form of binary twins, though occasionally in simple individuals. Multiple

Tertiary rocks —*Cont.*

striation is very infrequent. In addition to these lath-shaped sections of felspar, other rude rectangular sections occur, some striated, but the majority not. A little sanidine might be present amongst the unstriated individuals, and, without a separation of the felspars, its determination would be a matter of extreme difficulty.

The mica, which occurs in porphyritic individuals sparsely distributed through the rock, is quite fresh, of a deep brown colour, strongly pleochroic from light straw-yellow to deep brown, holds numerous inclusions of iron ore, and occasionally exhibits evidence of magmatic resorption. Little scales of this mineral are also scattered through the mass of the rock.

Slender little prisms of zircon, well terminated, are not infrequent in the section; also apatite crystals, and iron ore. The whole section is stained with yellowish-brown decomposition products.

As regards the groundmass of this rock, its felspathic constituents have already been described, but in addition to these there appears to be a certain amount of glassy interstitial matter, and the small plagioclase crystals are arranged in such a manner as to give a "flow-structure" to the rock.

Owing to the fact that the rock, as seen in the hand specimen, bears a striking resemblance to a typical trachyte, and also that the majority of the felspar individuals exhibit binary twinning only, it was thought advisable to make a separation of the felspars in order to be certain that plagioclase, and not orthoclase, is the predominating constituent.

The rock was finely powdered in an iron mortar, and the powder passed through, first, a sieve having 43 meshes to the square inch, and, finally, through one of 160 meshes to the square inch. The powder, after having a powerful magnet passed through it in order to remove any particles of iron which might have become detached from the mortar, was carefully washed and placed in a Harada apparatus filled with Thoulet's solution of specific gravity 2·670, as determined by a float of anorthite. It was found that all the powder, with the exception of a very little dark-coloured material, which was mostly mica, floated at this specific gravity. It also floated readily at 2·62. The solution was further diluted until a float of perthite (sp. gr. 2·592) just rose. At this specific gravity all the constituents sank very slowly to the bottom. The exact density of the fluid was then determined, and found to be 2·598; so that the powder must have a specific gravity of slightly over 2·60. This is the specific gravity of a felspar having the composition of albite, or of the heaviest anorthoclase.*

* See Rosenbusch, Mik. Phys. d. pet. wicht. Min., 2nd Ed., 1885, pp. 542 and 550.

Tertiary rocks —*Cont.*

It has frequently been observed that in the andesites the felspars of the groundmass are more acid than those which occur porphyritically developed. Fouqué has shown that in a pyroxene andesite from Santorin the former are albite and the latter labradorite.

72. Hornblende Andesite.—North side Maiden Creek. 327 (1889).

A light brownish-gray, rusty weathering rock; consisting of a fine-grained matrix in which are embedded rather large prismatic crystals of hornblende.

Cavities filled with carbonates are numerous in the specimen, and on the outer surfaces of the rock the removal of the carbonates by weathering gives it a cavernous appearance.

Phenocrysts of hornblende and plagioclase occur in a microcrystalline groundmass composed of the same materials, in which, if any glass be present, it must exist in extremely small proportions as minute films between the grains.

The hornblende phenocrysts are brownish-green in colour, and possess rather strong pleochroism, the axis of least elasticity bisecting the acute angle. The maximum extinction angle observed was about 25°. Inclusions of the other minerals present in the section are numerous, and alteration to chlorite was observed. Twinning according to $\infty P\bar{\infty}$ (100) is common. One individual is cut in a direction at right angles to the principal axis by a crystal of plagioclase, so that the section resembles a cross, the shorter cross-piece being formed by the plagioclase.

73. Basalt.— Hills between Loon Lake and Hi-hium Lake. 23 (1889).

A dark-gray, compact, fine-grained rock, which is quite fresh, and consists essentially of minute lath-shaped crystals of plagioclase, small grains and crystals of augite, and numerous granules of iron ore, embedded in a very fine-grained microfelsitic and glassy groundmass.

Patches and streaks of the groundmass, almost entirely free from plagioclase and augite individuals, occur throughout the section.

The plagioclases vary considerably in size, the smallest being mere microlites.

The augite individuals are usually very small, but, when examined with a high-power objective, are frequently seen to have good crystal forms, sometimes polysynthetically twinned.

A very few individuals of plagioclase and augite of a comparatively large size are present, and around these the smaller plagioclases bend in a manner which gives a typical "flow-structure" to the rock.

The section is somewhat stained with hydrous iron oxides.

Tertiary rocks —*Cont.*

The rock is one which, according to Rosenbusch's system of classification, would be referred to the basalts, although, disregarding age, it is often well-nigh impossible to draw the line between the augite porphyrites and the basalts. Taking into consideration the freshness and glassy character of the rock, together with its Tertiary age, the writer prefers to refer it to the basalts.

74. Basalt.—Arrowstone Hills, 2 miles south of Scottie Creek. 20 (1889).

An exceedingly fine-grained, compact, light-gray rock, having a strong argillaceous odour.

Owing to the extreme fineness of grain, a satisfactory microscopic examination of the section is a matter of some difficulty. It appears to consist chiefly of minute lath-shaped crystals of plagioclase, together with little irregular grains, and occasionally eight-sided sections, of a pale yellowish-green bisilicate (usually considerably altered) having a highly inclined extinction angle, which is undoubtedly augite.

The plagioclases have a general parallel arrangement and bend around the larger augites. Glassy matter is apparently present in the groundmass, lying between the plagioclases, but this could not be definitely proved in the section examined.

75. Olivine basalt.—Plateau, near Middle Branch of Tranquille River, north of Kamloops Lake. 355 (1889).

This is a very dark-coloured, somewhat porous, compact, fine-grained, porphyritic rock, with a decidedly resinous lustre, and exhibiting distinct flow-structure in the hand specimen.

A microscopic examination shows it to be a most typical and quite fresh basalt.

Plagioclase, hornblende, augite, olivine, and iron ore, occur porphyritically developed in a fine-grained groundmass made up of brownish glassy matter with embedded minute crystals and granules of plagioclase and augite; the whole possessing a well-marked flow-structure.

The porphyritic plagioclases often include portions of the glassy groundmass.

The hornblendes are brown in colour, and almost always have a dark rim surrounding them, composed of opaque iron ore and grains of augite. These rims are due to magmatic resorption of the hornblende.*

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*Cf. Iddings's translation of Rosenbusch's Microscopical Physiography of the Rockmaking Minerals, 1893, p. 268.

Tertiary rocks —*Cont.*

The olivine is almost entirely decomposed, and is now represented largely by rounded irregular patches of serpentinous material.

The augites are of a light yellowish colour and quite fresh.

76. Olivine Basalt.—Upper Tranquille River. 353 (1889).

A very dark-coloured, rather fine-grained, somewhat porphyritic, basic rock, which the microscope shows to be tolerably fresh and composed chiefly of plagioclase, augite, olivine, and iron ore.

Glassy, well-striated crystals of plagioclase occur porphyritically developed amongst the other constituents.

There is an abundance of serpentine developed all through the section as a decomposition product. It often has no definite form, as it would naturally have if derived from the alteration of augite or olivine, but occurs as little wedges in between the plagioclases; in such cases, perhaps, resulting from the decomposition of a glassy base. It probably originates from both sources, as it is also frequently seen surrounding cores of unaltered pale-green olivine and augite.

Owing to their extreme alteration, it is somewhat difficult to distinguish at first between the augite and olivine, but some elongated crystals with parallel extinction and, when fresh, brilliant polarization colours, were unhesitatingly referred to the latter mineral. Microlites of augite are exceedingly abundant, and granules and crystals of iron ore are evenly and plentifully distributed through the section.

77. Olivine Basalt.—Plateau west of North Thompson River, east and north of Caribou Lake. 193 (1888).

A medium-grained, rather light gray, crystalline, micro-porphyritic and amygdaloidal rock, which weathers to a rusty-brown colour. The amygdaloidal cavities are frequently lined with some zeolitic mineral.

The rock is composed chiefly of plagioclase, augite, olivine and iron ore.

The plagioclase occurs in broad porphyritically developed forms, as well as in lath-shaped sections in the groundmass of the rock, these latter forms frequently penetrating the augite. The phenocrysts are fresh, glassy, well-striated, and hold numerous inclusions of augite, iron ore, and other minerals, often arranged in lines around the periphery of the crystal. Determinations of the angle of extinction, measured on P, appear to show that the felspar is to be referred to bytownite. The crystals have very irregular boundaries, due to magmatic absorption, and the smaller plagioclases of the groundmass bend around them in the usual manner observed in those rocks which exhibit "flow-structure."

The groundmass plagioclase is frequently intergrown with the augite, often in such a way as to make it probable that they crystallized simultaneously. Tertiary rocks —*Cont.*

The augite is of a violet-brown colour, quite fresh, rather strongly pleochroic, and exhibits brilliant interference colours. It does not occur with regular crystal outlines, but intergrown with, lying between, and sometimes almost completely surrounding, the plagioclases.

The olivine is very abundant in irregular pale olive-green grains, which are usually quite fresh, although many examples of alteration to brown serpentine, accompanied by separation of magnetite, may be seen in the section. It possesses the usual high index of refraction, brilliant polarization colours, and other features characteristic of the mineral.

Iron ore, probably magnetite, is extremely abundant, mostly in irregular grains and rods.

The structure of the rock is apparently a holocrystalline one, and if glassy matter be present it must exist in very small quantity.

78. Olivine Basalt.—Skoatl Point. 194 (1888).

In the hand specimen this is a dark greenish-gray, rather fine-grained, porphyritic rock. Dr. Dawson states that it forms the " neck " of an old volcano from which basalt has flowed out, and is probably of Tertiary age.

Phenocrysts of plagioclase, olivine, and augite, are embedded in a fine-grained groundmass composed of lath-shaped sections of plagioclase and granules of augite, olivine, and magnetite, together with some glassy interstitial matter.

" Flow-structure " is sometimes well brought out by the arrangement of the small plagioclase crystals in the rock.

Olivine is very abundant and remarkably fresh, exhibiting only the first stages of alteration to serpentine. It occurs in little grains in the groundmass, as well as in porphyritically developed individuals. Its outlines are often rounded, a phenomenon which is no doubt due to magmatic resorption. It is frequently included in the felspar, thus showing that it is the older of the two, and itself holds numerous inclusions. In colour it is yellowish to almost colourless, and possesses good cleavage.

79. Tuffaceous Rock.—Thompson River, opposite Drynoch. 188 (1889).

Tertiary rocks —*Cont.*

A coarse-grained, light greenish, apparently clastic rock, consisting very largely of fragments of plagioclase felspar, which are greatly decomposed.

The fragments representing bisilicates originally present, are now so entirely altered as to be unrecognizable. The section contains some quartz, also much calcite, chlorite, and other decomposition products. The rock is probably made up of material derived from basic eruptives.

[The following description is by Dr. F. D. Adams, of McGill University, who examined a thin section of the rock in question.]

79*a*. ALNÖITE-LIKE ROCK.—Road between Ashcroft and Savona, three miles east of Eight-mile Creek. 441 (1877).

A rock consisting of a very fine-grained groundmass in which are embedded large phenocrysts of biotite, augite, and olivine.

In the hand specimens the large plates of biotite are especially noticeable, giving the rock the appearance of an alnöite.

The olivine is now all decomposed to serpentine, or a mixture of serpentine and a rhombohedral carbonate; the biotite is also much altered. The augite is nearly colourless and possesses a barely perceptible pleochroism, these large augites are often surrounded by a darker border of a different variety of augite with a somewhat different extinction,—as in the alnöite from Ste. Anne de Bellevue,*—the small augites of the groundmass are identical in character with the outer zone.

The groundmass is composed largely of augite in little crystals. Associated with this are biotite and olivine, now for the most part altered to serpentine, together with a colourless mineral having a very low double refraction, little grains of iron ore, and little needles of apatite. The colourless mineral above referred to has never been observed twinned and is certainly not plagioclase. It is for the most part decomposed to calcite, this fact and its optical properties so far as they can be studied, point to nepheline or possibly mellilite. None of the distinctive characters of the latter mineral, however, could be observed, but so little of the undecomposed mineral still remains that its exact nature cannot be determined.

The rock, therefore, is one belonging to the group which includes the alnöites, monchiquites, and fourchites, but it is now so decomposed that its exact position in this group cannot be determined.

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* See Adams, Am. Jour. Sci., vol. XLIII., 1892, p. 269.

Dr. Dawson states that the rock is probably a dyke of Tertiary age, but that the rocks at the locality are much broken and confused.

41. Quartz Augite Diorite, with some Biotite.—Forge Mountain. 32 (1890). Plutonic rocks.

A medium-grained granitic rock, showing in the hand specimen light grayish felspar, dark green hornblende, and magnetite.

The microscope shows it to consist essentially of quartz, plagioclase, orthoclase, hornblende, augite, and biotite, together with magnetite, apatite, chlorite, epidote, titanite and zircon.

The quartz is the ordinary granitic variety, filling-in the spaces between the felspars.

Plagioclase is the predominating felspar, and occurs in broad, well striated, much altered, often nearly opaque, individuals, with a decided tendency to idiomorphic development. Some non-striated irregular-shaped grains, also much altered, are probably orthoclase.

The hornblende occurs in brownish-green individuals, sometimes possessing a somewhat fibrous structure, and often interspersed with augite. Twins are not uncommon, and the mineral usually exhibits more or less alteration to chlorite, and is sprinkled with granules of magnetite and other inclusions.

Augite, besides occurring as described, associated with the hornblende, is also present in isolated individuals, generally much altered to chlorite, bright yellow epidote, and calcite, the brown colour being changed to green. Lenticular patches of calcite filled with minute needles and granules of epidote, causing the whole to polarize most brilliantly, have separated out between the folia of the hornblende.

80. Quartz Mica Diorite.—Near Pukaist Creek, three miles east of Thompson River. 35 (1890).

A medium-grained, holocrystalline rock, in which the felspar, of a light greenish colour owing to alteration, is mottled with dark-coloured hornblende and biotite.

It is composed of plagioclase, orthoclase, quartz, biotite, hornblende, pyroxene. magnetite, apatite, and epidote.

The plagioclase, which predominates largely over the orthoclase, possesses uneven extinction, shows a marked tendency towards idiomorphic development, and is, together with the orthoclase, much decomposed.

Quartz is tolerably abundant, extinguishes very unevenly, and occurs in little granulated areas throughout the section.

Plutonic rocks—*Cont.*

Biotite is plentiful, largely altered to chlorite and epidote; the hornblende also is much decomposed and occurs intimately associated and intergrown with the biotite and pyroxene.

The monoclinic pyroxene is quite abundant in the section, is of a pale green colour, and considerably altered to epidote and a light-green chlorite. Little granules of secondary magnetite are plentifully scattered through the altered crystals of this mineral. Frequently a core of comparatively fresh pyroxene may be seen surrounded by fibrous hornblende, which no doubt has resulted from its alteration.

The bisilicates are all much stained by brown hydrous oxides of iron.

81. Quartz Mica Diorite.—Six miles up In-ki-kuh' Creek. 36 (1890).

A rather coarse-grained holocrystalline rock, consisting of a light-coloured quartz and felspar matrix, in which numerous flakes of dark-brown mica of good size, and smaller individuals of hornblende and iron ore are embedded.

The minerals composing it are plagioclase, orthoclase, quartz, biotite, hornblende, magnetite, titanite, apatite, epidote, chlorite, and zircon.

The plagioclase felspar is the more abundant, is well-striated, and considerably altered to saussuritic material. It possesses, in common with the orthoclase and quartz, a very uneven extinction, due to pressure.

The biotite shows decompositions and alteration to chlorite, and, consequently, often presents a somewhat fibrous appearance. The hornblende, also considerably altered, presents no unusual features. It is strongly pleochroic in green and yellowish-brown tints.

Titanite and magnetite are abundant, often occurring in large grains. A few short, stout, crystals of zircon were observed, sometimes embedded in the biotite.

82. Crushed Granite.—Guichon Creek, west side, one mile south of Witches Brook. 26 (1890).

This is a fine-grained, light greenish, somewhat rusty, granitic rock, possessing in the hand specimen a distinct finely-laminated structure. It is stated by Dr. Dawson to occur near the contact of a mass of granite with rocks of Triassic age.

Under the microscope it is seen to consist of a fine-grained interlocking mosaic of quartz and felspar, in which larger grains of the same materials are embedded.

Little scales and a few larger flakes of biotite, sometimes altered to chlorite, are scattered plentifully throughout the rock, and grains of magnetite are also abundant. Small quantities of apatite and titanite are also present. Plutonic rocks—*Cont.*

Orthoclase and plagioclase both occur in a greatly decomposed condition and exhibit, together with the quartz, very uneven extinctions, having evidently been subjected to intense dynamic action. The larger grains are much cracked, and reduced to a fine mosaic of crushed material around their edges.

A rude laminated structure is given to the rock in the thin section by the parallel arrangement of the flakes of biotite. It is most probably a granite which has been subjected to great crushing action.

83. GRANITE PORPHYRY.—East side of Barnes Lake. 48 (1889).

A medium-grained, light greenish-gray, granitic rock ; blotched with porphyritic, olive-green, decomposed felspar.

It is composed essentially of orthoclase, plagioclase, quartz, and very small quantities of some much altered bisilicates, together with iron ore, chlorite, epidote, apatite, sphene, and hydrous oxides of iron.

Many portions of the section examined show a distinct coarse granophyric intergrowth of the quartz and felspar. The latter occurs sometimes in large, porphyritically developed, crystals ; and the whole structure of the rock suggests the first transition stage of a granite passing into a quartz porphyry.

The rock, as far as one can judge from the single section, is holocrystalline, no glass or interstitial matter being detected.

The felspars are so exceedingly altered that the irregular grains of the quartz stand out in bold relief, giving at a first glance an almost clastic appearance to the section.

Bisilicates occur in very insignificant quantities, and are mostly represented by brownish chloritic and epidotic material, associated with granules of iron ore. In a few instances the original mineral was judged to have been biotite. Iron ore, probably magnetite, is quite abundant, and several small grains of sphene were also observed.

84. PORPHYRITIC DIABASE.—Road between Ashcroft and Savona, six miles from Ashcroft. 129 (1890).

This is a medium-grained, dark-green and yellowish-brown mottled rock, in which the microscope shows a fine-grained portion, having the ophitic structure of a diabase, and holding porphyritically developed crystals of plagioclase and augite.

Plutonic rocks—*Cont.*

The plagioclase phenocrysts show an extreme stage of alteration to saussuritic material.

The whole rock is much decomposed, and consists chiefly of plagioclase, pyroxene, biotite, a little quartz, iron ore, apatite, and pyrite.

Both augite and diallage are present in the rock and are greatly altered to chloritic, serpentinous, and epidotic material, with deposition of granules of secondary magnetite. The augite is light-green in colour and polarizes in brilliant tints. The phenocrysts of this mineral are greatly decomposed.

Two sections of this rock were examined, one of which contains much more biotite than the other. The biotite is of a curious deep reddish-brown colour, and strongly pleochroic. It is apparently secondary in origin, and occurs intimately associated with the confused tufted and fibrous aggregates of serpentinous and chloritic material resulting from the decomposition of the bisilicates. The iron ore is chiefly ilmenite, accompanied by leucoxene. This rock, No. 96, and No. 99, resemble each other in the hand specimens and have the same general mineral composition, but the rock now under consideration is porphyritic, and exhibits a phase of structure more closely approaching that of a coarse-grained porphyritic diabase. The difference in structure would readily be produced by a difference in the rate of solidification of the magma.

85. Biotite Hornblende Granite, or Hornblende Granitite.—Summit of Chi′-pocin Mountain. 266 (1889).

In the hand specimen the rock presents the same general appearance as No. 92. It is thoroughly holocrystalline, consisting principally of orthoclase, plagioclase, quartz, biotite, and hornblende; with titanite, iron ore, apatite, zircon, chlorite, and epidote, as accessory constituents.

The felspars, as a rule, are not greatly altered, although some individuals show more or less complete saussuritization. Zonal structure is common; they also possess very uneven extinction, and are filled with various inclusions, amongst which are little blood-red transparent scales of hematite. The plagioclase felspar is quite abundant and frequently exhibits excellent examples of pressure-twinning.

The quartz is the usual granitic variety and forms a rather fine-grained mosaic between the felspars.

Biotite is abundant, quite fresh, strongly pleochroic, and often intergrown with hornblende, which presents no unusual features and is frequently altered to chlorite.

Titanite is abundant, occurring mostly in large irregular grains: apatite is also present in small, rather stout, crystals. Several stout crystals of zircon, showing a zonal structure, were observed. Plutonic rocks—*Cont.*

Chlorite, epidote, and iron ore are abundant, the latter sometimes accompanied by a substance which is apparently leucoxene, indicating that some titanic iron is present; but a test of the powdered rock showed that magnetite is very abundant.

As regards the nomenclature of this rock and No. 92, much plagioclase is undoubtedly present, and a separation of the felspars in each case would be necessary in order to determine whether the rocks might not perhaps be more properly termed quartz diorites. In the absence of such determinations, and from a close examination of the sections submitted to me, I prefer at present to refer them to the granites.

86. HORNBLENDE GRANITE.—Three-lake Valley. 386 (1877).

A medium-grained, light pinkish, decomposed granitic rock, which, judging from the hand specimen, has a "miarolitic" structure; that is, it possesses small cavities into which the corners and edges of the crystallized mineral components project.*

It consists of a holocrystalline aggregate of orthoclase, plagioclase, hornblende, apatite, and iron ore; with epidote, chlorite, kaolin, and hydrous iron oxides, as decomposition products. Little areas of granophyre are numerous in the section.

The quartz is the ordinary granitic kind and holds numerous nclusions. The felspars, especially the plagioclase, are greatly decomposed to a dull whitish opaque substance. The bisilicates originally present are now almost entirely altered to chlorite, epidote, etc. Some comparatively unaltered fragments, which were examined carefully, proved to be hornblende. Aggregates of brilliantly polarizing epidote granules are abundant.

Both magnetite and ilmenite appear to be present, the latter frequently accompanied by leucoxene resulting from its alteration.

87. HORNBLENDE BIOTITE GRANITE.—Between Campbell Creek and Kamloops. 108 (1889).

A medium-grained, holocrystalline rock, exhibiting in the hand specimen a light-coloured groundmass, blotched with dark hornblende and mica, and somewhat stained with hydrous iron oxides. It approaches in composition to the quartz diorites, in that plagioclase felspar is very abundant, equalling in quantity, if indeed it does not exceed, the orthoclase.

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* *Cf.* Rosenbusch, Mik. Phys. der mass. Gesteine, p. 39, 1887.

Plutonic rocks—*Cont.*

The minerals present are quartz, orthoclase, plagioclase, hornblende, biotite, ilmenite, titanite, apatite, zircon, and pyrite. The quartz is the ordinary granitic variety, is much cracked, and possesses very uneven extinction in common with the felspars. Both orthoclase and plagioclase are considerably decomposed; the latter is well striated and often possesses a marked zonal structure. It also exhibits a tendency to idiomorphic development, and the same crystal, in addition to the ordinary fine twinning striation, will frequently shew twinning on the Carlsbad plan.

The hornblende, which is tolerably unaltered, occurs in irregular individuals, and also in well defined crystals which are strongly pleochroic in light yellowish-brown to dark green tints. The crystals are frequently twinned parallel to the orthopinacoid.

The biotite presents a fibrous frayed-out appearance and is altering to chlorite. Zircon and apatite are among its included minerals.

Titanite and iron ore are not very abundant in the section.

The rock in its general characters somewhat resembles a granite from the Stikine River, described by Dr. Adams.*

88. Crushed Granite.—North side of Kamloops Lake, near Copper Creek. 161 (1890).

A rather coarse-grained, much decomposed, light grayish, granitic-looking rock, holding numerous patches of rather bright yellow altered felspar; the whole spotted with small rusty dolomite and calcite crystals and little spangles of silver-white mica, the former giving a general pinkish hue to the specimen. It effervesces freely with dilute hydrochloric acid.

A microscopical examination shows it to be made up chiefly of fragments of quartz and felspar cemented together by a fine mosaic of the same materials, affording a good illustration of Törneböhm's "mortar-structure" (Ger. *mörtelstructur.*†)

Numerous irregular patches and small crystals of very rusty carbonates are scattered throughout the section, together with scales of pale green chlorite and a colourless hydro-mica. A few small zircon crystals were also observed. Patches of granophyre are not uncommon, sometimes surrounding felspar individuals.

Both orthoclase and plagioclase are present, generally in a much altered condition, the larger grains, together with the quartz, being cracked, bent, and granulated on their edges.

* Annual Report, Geol. Surv., Can., vol. III. (N.S.), Part I., 1887-88, p. 238 B.

† Geol. Fören. Förhandl, 1881, V, p.233.

Plutonic rocks—*Cont.*

The quartz shows uneven extinction in a less degree than does the felspar, but is much broken. The rock is probably a granite which has been subjected to great crushing action.

89. SYENITE (PORPHYRITIC).—Edwards Creek. 81 (1889).

A rather coarse-grained, holocrystalline, light pinkish or yellowish-gray rock, with large porphyritic felspar crystals thickly scattered through it. Its texture varies considerably in different portions of the mass. That it has been considerably squeezed is shown by the crushing and undulatory extinction of the component minerals.

The minerals composing it are orthoclase, plagioclase, microcline, biotite, some hornblende largely altered to chlorite, titanite, ilmenite, apatite, zircon, calcite, epidote, sericite, and pyrite.

Very little, if any, quartz is present. It was searched for amongst the crushed mosaic of felspar grains lying between the phenocrysts, but could not be identified with certainty. The felspars are much decomposed and often exhibit a zonal structure. Titanite is very abundant in large irregular single grains and aggregates, and is frequently associated with ilmenite. An exceedingly minute yellow metallic particle was thought to be gold, and Dr. Dawson has since informed me that an assay has been made which showed that appreciable traces of that metal exist in the rock.

90. AUGITE SYENITE. North Branch Bonaparte River, near the mouth. 336 (1889).

A rather coarse-grained holocrystalline rock, which in its structure differs somewhat from a typical syenite.

The principal mineral constituents are orthoclase, microcline, augite, biotite, apatite, magnetite, and zircon. Quartz was not detected in the section examined.

The orthoclase presents the usual characteristics of the variety commonly occurring in granites. A curious micro-perthitic intergrowth of the felspars is of very common occurrence. A felspar resembling anorthoclase is rather abundant in the section in very finely striated grains. In sections at right angles to P and M this felspar exhibits a very fine microcline-like twinning striation.*

The augite is of a clear light-green colour, occurring in irregular grains and sometimes in rude octagonal sections. It is often intimately associated with the biotite, which is of a deep brown colour and strongly pleochroic.

* Rosenbusch, Mik. Phys. d. pet. wicht. Min., 3rd Ed., 1892, pp. 679-680.

Plutonic rocks—*Cont.*

Apatite in large stout crystals and irregular grains is very abundant Magnetite is also plentiful, and a few zircons were observed.

The rock shows considerable saussuritization of the felspars, and the section is stained throughout with brownish decomposition products resulting probably from the alteration of bisilicates.

91. Hornblende Granite.—East side Fraser River, seven miles north from mouth of Cinquefoil Creek. 274 (1889).

This is a medium-grained, dark-green and white rock, which, examined microscopically, is seen to be composed chiefly of orthoclase, quartz, hornblende, and a little plagioclase felspar; also titanite, epidote, chlorite, and iron ore.

Cataclastic structure is remarkably well-developed, the very uneven extinction and crushing of both quartz and felspar being evidence of the intense dynamic action to which the rock has been subjected.

The felspar, as usual, is not so badly shattered as the quartz, but, like it, possesses very uneven extinction. The quartz shows every gradation from slightly uneven extinction to complete shattering of the grains. The hornblende is intensely pleochroic in yellowish-brown to deep green tints, and is altering to chlorite and epidote. Much titanite and epidote are present, the former often in rude crystals as well as in irregular grains.

92. Biotite Hornblende Granite, or Hornblende Granitite.—East side of Fraser River, four and a half miles above Cinquefoil Creek. 273 (1889).

This rock, whilst resembling No. 91 in the hand specimen, does not exhibit such marked cataclastic structure when microscopically examined. Biotite is also present, and plagioclase is much more abundant.

Its component minerals are orthoclase, plagioclase, quartz, biotite, hornblende, iron ore, chlorite, apatite. zircon, epidote, and titanite.

The felspar is considerably altered, and frequently exhibits a beautiful zonal structure. Biotite is abundant in quite large individuals, often bleached and altered to chlorite. The hornblende, also showing alteration to chlorite, occurs intimately associated and intergrown with the biotite. Iron ore in irregular grains is very abundant, and sometimes accompanied by a grayish substance resembling leucoxene; so that the iron ore in these instances is no doubt ilmenite.

93. Quartz Mica Porphyrite.—Kl-qw-a Mountain. 76 (1890).

In the hand specimen this is a grayish-white, fine-grained, compact, felsitic-looking rock, through which are distributed numerous porphy-

ritic individuals of quartz, felspar, and a dark-coloured, almost black, mica. Plutonic rocks—*Cont.*

Seen under the microscope the groundmass of the rock consists of a very fine-grained mosaic of quartz and felspar, in which the phenocrysts of quartz, felspar, and biotite, are embedded together with garnet, epidote, chlorite and apatite. Very few phenocrysts are present in the section examined, but these appear to consist chiefly of plagioclase.

An examination of quite a number of sections would be necessary to determine the question as to whether the rock should be referred to the porphyrites, in which plagioclase predominates, or to the porphyries, in which orthoclase is the prevailing felspar. Dr. Dawson states that the rock forms a dyke cutting granite of the Coast Range.

94. QUARTZ PORPHYRY, PASSING INTO QUARTZ PORPHYRITE.—North side of Seton Lake. 297 (1889).

A very light coloured, grayish-white, medium-grained, granitic-looking rock, occurring, according to Dr. Dawson, in the form of a large dyke.

Under the microscope it is seen to possess some remarkable features.

Porphyritic crystals of quartz which are sometimes sharply idiomorphic, together with idiomorphic plagioclases, are embedded in a micro-granitic groundmass which is apparently chiefly composed of grains of unstriated felspar, and perhaps a little quartz, although the latter mineral was not determined with certainty.

The porphyritic plagioclases show well-developed zonal structure, and often occur in interpenetrating twins with the usual striation.

A determination of the extinction angles shows that they are intermediate in composition between oligoclase and labradorite, with the centre more basic than the outer portion.

Small quantities of biotite and hornblende, much altered to chlorite, are present.

The rock is altogether a remarkable one ; the plagioclase is unusually basic to be associated with so much quartz, and there is an unusually small quantity of coloured bisilicates for a porphyrite.

Sections were submitted to Dr. F. D. Adams and Prof. A. P. Coleman, and the writer is much indebted to these gentlemen for their views regarding the rock. They agree with him in regarding it as a quartz porphyry, which, from the large amount of plagioclase present, is passing into a quartz porphyrite.

Plutonic rocks—*Cont.*

95. AMPHIBOLITE.—Stein Mountain. 83 (1890).

A fine-grained, dark-green, somewhat schistose rock, in which the microscope reveals the fact that it has been subjected to intense dynamic action, and so sheared and crushed as to almost entirely obliterate its original structure.

Finely granulated plagioclase, the individual grains of which exhibit very uneven extinction, is mingled with confused aggregates of hornblende, chlorite, muscovite, and a dark-brown mica, these minerals also occurring in isolated scales and minute crystals scattered through the felspar.

Many forms occur almost entirely altered to chlorite or some other substance, an alteration accompanied by the separating out of magnetite in small granules, which are now thickly sprinkled through the mass. These forms, by their general appearance, suggest that the original mineral may have been pyroxene.

Zircon, apatite, and little cubes of pyrite mostly altered to limonite, were observed, and the whole section is permeated by hydrous oxides of iron, to which its brown coloration is due. The hornblende is largely in the form of slender needle-like crystals which are probably actinolite.

The constituent minerals as seen in the section have a distinct parallel arrangement, and the rock, which Dr. Dawson informs me occurs as a dyke cutting granite, is doubtless a much squeezed and altered basic eruptive.*

96. GABBRO.—North end of Coal Hill Ridge, near the road. 1 (1888)

A medium-grained, dark-green rock, mottled with whitish felspar.

It has a granitic structure, and is composed of plagioclase felspar, augite, ilmenite usually accompanied by leucoxene, chlorite, and epidote. The specimen is in an advanced stage of alteration, the felspar being changed almost entirely to a confused mass of saussuritic material.

The augite, though less altered than the felspar, is changing in many instances to pale green chloritic and serpentinous substances. Twinned grains are not infrequent. Iron ore is quite abundant.

97. GABBRO, APPROACHING DIABASE IN STRUCTURE.—Behind Battle Bluff. 202 (1888).

This is a mottled, pink and dark-green, rather coarse-grained and much decomposed rock, consisting chiefly of plagioclase, augite, a little quartz, and ilmenite, together with epidote, chlorite and apatite.

* See notes on Nos. 8 and 9, pp. 352-353 B.

The plagioclase is almost completely saussuritized, and the augite, which is much cracked, is largely altered to chlorite and epidote. Plutonic rocks—*Cont.*

Ilmenite, accompanied by its alteration product leucoxene, is abundant. Epidote is also plentiful and is intensely pleochroic, from deep yellow to almost colourless.

Apatite in irregular grains and crystals is of frequent occurrence.

The plagioclase individuals are broad, and the structure of the rock is intermediate between that of a gabbro and that of a diabase, some portions of the sections showing an approach to the granitic structure of the former, whilst others again have a coarse ophitic structure.

On the whole, the writer is inclined to refer the rock to the gabbros rather than to the diabases.

98. Gabbro, approaching diabase in structure.—Near Edith Lake. 249 (1890).

A fine-grained, pale green, decomposed rock, consisting of plagioclase, augite, iron ore, chlorite, epidote, and apatite.

As seen in the thin section the rock is greatly altered, the plagioclase felspar being partly converted into saussurite. A curious regular "lattice-structure" is often to be seen in the arrangement of the scales of sericite derived from the alteration of the plagioclase.

The rock does not possess a strictly typical gabbro structure, portions of it showing a very coarse ophitic structure, which tends to ally it with the diabases.

The augite is very pale green to colourless when fresh, but is generally much altered to chlorite and epidote. It exhibits a tendency to idiomorphic development. Iron ore, probably magnetite, is abundant. This specimen must be classed with No. 97 as regards its structure.

99. Porphyritic Diabase.—Cherry Bluff. A (1888).

This rock in the hand specimen is fine-grained, of a dark olive-green colour, with porphyritic crystals of plagioclase felspar, which, in comparison with the main mass of the rock, are of large size. Augite also occurs porphyritically developed, in exceedingly decomposed crystals.

The structure of the specimen is that of a typical diabase, its ophitic character being marked, and it possesses but very little groundmass.

The plagioclase felspar, though not extremely altered, is much cracked, full of inclusions, extinguishes very unevenly, and is stained with brown decomposition products derived from the augite. It often forms binary twins, and possesses a most beautiful zonal structure. A number of determinations of the angle of extinction, measured between

Plutonic rocks—*Cont.*

two adjacent lamellæ, shows that it is to be referred to the labradorite group of the plagioclase series.

Both the augite filling the interstitial spaces of the felspar and that porphyritically developed, are extremely altered to a deep yellowish-brown serpentinous substance. Some of this decomposition product may possibly represent olivine originally present in the rock, but this is somewhat doubtful, and could not be proved in this particular instance. Iron ore, probably magnetite, is plentiful, sometimes possessing sharp crystal outlines. A few minute zircons were seen. Apatite and epidote are also present.

100. Tuffaceous Rock.—Cherry Bluff, near west end. B (1888).

A rather fine-grained, olive-green, rusty weathering rock, which, as shown by the microscope, possesses a distinctly clastic structure and is made up of fragments of felspar (some untwinned grains occur in addition to undoubted plagioclase), augite, much epidote, chlorite, and iron ore. No quartz was observed in the section, which is stained with hydrous oxides of iron.

Only a comparatively small amount of unaltered pale green augite remains, the large quantity of epidote and chlorite observed having no doubt in great part resulted from the decomposition of that mineral, and perhaps of other bisilicates originally present in the rock.

Although thus shown to be of clastic origin, this rock is placed here because indistinguishable from the main eruptive mass of Cherry Bluff, in which it has been caught up.

APPENDIX II.

SHUSWAP NAMES OF PLACES WITHIN THE AREA OF THE KAMLOOPS MAP-SHEET.

[Extracted from a paper entitled *Notes on the Shuswap People of British Columbia*, by GEORGE M. DAWSON. Trans. Royal Soc. Can., vol. IX., (1891) sect. II.]

The alphabet employed is identical with that of the "Comparative Vocabularies of the Indian Tribes of British Columbia," and is as follows :—

Vowels.

a,	as in English	fat.
ā,	" "	father.
e,	" "	met.
ē,	" "	they.
i,	" "	pin.
ī,	" "	marine.
o,	" "	pot.
ō,	" "	go, show.
u,	" "	nut, but.
y,	" "	year.
ai,	" "	aisle.
ei,	" "	vein.
oo,	" "	pool, fool.
eu,	" French	peu (seldom used).
ow,	" English	now.

The distinction of long and short vowels (following Gibbs) is noted as far as possible, by the division into syllables,—the consonant that follows a vowel being joined immediately to one intended to be pronounced short, while a long vowel is left open, being followed by a hyphen. When this is insufficient, or a nicer distinction is desirable, the usual long and short marks are supplied.

Explosive or klicking sounds are represented by the letters k, t, etc., in combination with an apostrophe, thus 'k 't.

An acute accent (′) at the end of a syllable indicates its accentuated character, when this is very distinct. Strongly guttural syllables are printed in small capitals, thus,—law-KH.

Indian Names.	Name Adopted, or Description of Place on the Map.	Meaning Given for Indian Name.
A-kaz-ik′	A-kaz-ik′ Mountain	
As-kōm′	As-kōm′ Mountain	The Mountain.
Bōtānie	Botanie Lake, etc	Perpetual root-place. ?
Hai′-in-wolh	Deadman River	Circling or detour.
He-mām′-sitl	Big Fish Lake	Big Trout. ?
Hī-āh′-kwa	Hī-āk′wa Lake	Long Lake.
Hi-hium′	Hi-hium Lake	Trout Lake.
Hloo-lĕu	Lac le Bois	Diver Lake.
Hoom-it-ā′-lis	Stony Creek	
Hūm-ilt-kwē-ilt	Small lake below Big Bar Lake	Young Fish Lake.
Hup-hāp′	Hill on west side Copper Creek	Slaty.
Hut-tsat-tsl	Old village site near Kelley Lake	Cold Spring.
I-ĭs	Campbell Creek	
In-hā-hōt′	Eighteen-mile Creek	Dry.
In-ka-kēn	Mountain 4 miles north of Za-kwas′-ki	
In-ki-kuh′	In-ki-kuh′ Creek	Sometimes dry.
In-koi′-ko	In-koi′-ko Creek	
In-pa-āt′-kwa-ten	Pavilion Lake	
In-skwa-tām	Red Creek	Red.
In-tl-pam	In-tl-pam Creek	Deep.
In-toi-a′	In Marble Mountains	Overhung Mountain.
In-whois′-ten	Bridge River	
Ka-ka′-kowes	Pass Lake	
Kil-a-paus′	Lower part of Scottie Creek	
Kit-sa-min′	Edward Creek	Drift pile.
Klá-hăl	Loon Lake	
Klim′-la-la-me	Medicine Creek	Medicine.
Kl-ow′-a	Kl-ow-a Mountain and Creek	Green.
Kluh-tows	Bonaparte River	Gravelly River.
Kōk-lā-kā	Shumway Lake	
Kuk-waus′	Kuk-waus′ or Bonaparte Lake	Spear-head Lake ?
Kwil-āl′-kwila	Green Mountain	Green Mountain.
Kwin-tsha′-ten	Small stream joining Nicola above Skuh′-un	
Kwio-hau′k	Cairn Mountain	Open or clear.
Kwōm′-a-kun	Skull Hill	Skull hill.
La′-loo-wissin	La′-loo-wissin Creek	
Ma-mīt	Mamit Lake	Whitefish.
Me-toots′	At forks of Bonaparte	Projecting point.
Na-ai-ik	Guichon Creek, mouth	Bearberry (*Arctostaphylos*.
Na-kwās′-tam	Eleven-mile Creek	Deep.
Ne-kin-ish-tam′	Chasm Creek	
Ne-wil-whoos	Ridge lake	Ridge lake.
Ni-a-an′-tun	Botanie valley as a whole	
Ni-kow-men	Nicoamen River	
Ni-hlip-tow′-us-tum	Small stream next above Kelley Creek	Going-over stream.
Nim-nim-wh′	Mountain 4 miles north-east of Za-kwas′-ki	
O-o-pax′	Opax Hill	
Pe-tloosh-kwo-hap′	Pe-tloosh-kwo-hap′ Mountain	
Pi-mai-nus	Pimainus Creek and Lakes	
Pip-tsutl	Trout Lake	Trout.
Pis-ī-tsoots′-ī-a	Porcupine Ridge	Porcupine place.
Pis-kī-kī-al	Small lake near Ridge Lake	Chief-hare.
Ptl-mā′-mī-a	Fly Creek	Blue-bottle fly.
Ptl-nīl-min	Poison Hill	Poison-weed (*Veratrum*) place.
Ptl-tik-moos′	Young Lake	Sucker.
Puh-hā′-ha-nih	Ridge running west from Cairn M′t′n.	
Pu-kaist	Pu-kaist Creek and village	White.
Pu-kō′-kila-hoom	Big Bar Lake	Deep, with shallow margin.

Indian Name.	Name Adopted or Description of Place on the Map.	Meaning Given for Indian name.
Put-hil-i-hīl	Three-lake valley..................	*Potentilla anserina.*
Shaw-ow-itlan	Mouth of Jamieson Creek..............	The portage.
She-kŭk′-ilwh.....	Lower part of Sandy Creek............	
Shit-shoos′-tl.	Allen Creek	It dries up.
Shloot...........	Fraser River near Leon Creek.....	The eddy.
Shoopem-hāt′-kwa.	South Thompson............	Shuswaps' river.
Sil-whoi′-a-kun....	Sil-whoi′-a-kun........	Caribou place.
Sin-po-āt′-kwa	North Thompson.....................	North river.
Sī-o-kŭm	Trapp Lake..........................	
Sitz-kwōk′-sum....	1½ mile below Leon Creek.............	Looking up.
Sī-whe′	Sī-whe′ Creek	
Skem-a-kaim′.	Lower end of Seton Lake..............	
Skī′-hist....... .	Ski′-hist Mountain...................	
Ski-kloosha.	Face Lake...........	Face.
Skoon-kō′.........	Skoon-kō′ Creek................... ..	
Skoo-talis	Hills between Thompson, Bonaparte and Câche Creek.....	
Skoo-wat′-kum ...	Skull Creek.........	
Sko-whautl........	Skoatl Point..	Pointed or upstanding
Skuh′-un	Skuh′-un Creek....	Stony.
Skuk′-e-uke.......	Mountain 3 miles north-north-east of Za-kwas′-ki	Thunder hill.
Skup kak-wa......	Sandy Creek.....	Sandy.
Sku-skul-a-hāt′-kwa	River Lake.........	
Skutl-hēh-′-tl.	Gnawed Mountain.....................	Eaten to the bone.
Skwil-ā′-tin. ..	Kelley Creek, lower part..............	Big hill.
Skwil-kwa′-kwil ..	Skwil-kwa′-kwil Mountain.	The highest.
Spa-āīst	Spaist Mountain......................	Burnt.
Spāp-sil-kwa	Glen Hart...........................	The lakes.
Spa-tsin′.	Spa-tsin Lake........................	Burnt lake?
Spēp′-sum	Spatzum.........................	*Asclepias speciosa.*
Spi-al-hw.........	Eagle Hill	Eagle.
Spilim-āt′-lē-la ...	Near mouth of Câche Creek...........	Brook at the flat.
Spil-mā-moos......	Maiden Creek........................	Little flat.
Spīl-pāl′-um	Clinton Creek.........	Prairie flat.
Spit′-poo-tlum.. ..	Marble Cañon..........	Narrow valley which opens.
Spit-ti-kwous′.....	Pass from Hat Creek to Jack's Creek...	The defile.
Stā-ai′in *or* Ste-in..	Stein Creek	
Stlim′-what-kwa ..	Fraser River near Lillooet.............	Lillooet's river.
S′tl-pō′-mun	Upper part of Hat Creek valley........	Opening out.
Swuz-uk-ain′......	Botanie Mountain.....................	
Tai-a-ka	Tai-a-ka Lake........................	
Ta-tlh	Small stream 1 mile north of Fourteen-mile Creek........................	
Ti-hā-mia.........	Stump Lake	
Tik-ī-māx′........	Tranquille River..	Point (river).
Til-kwo-kwē′-ki-la.	Tranquille River, near mouth.........	Name of a root.
Til-kwa-sī-shoo....	One of the Red Lakes.....	
Titl′-whiloom......	Three-mile Creek	
Tlirt-lī-put-ām′....	Macaulay Creek......................	Balsam-fir ravine.
Toon-kwa	Toon-kwa Lake.......................	Goose lake.
Tow-il-ta-kaī......	Eight-mile Creek.....................	Mountain brook.
Tshi-it′-lin-stum...	Eating Lake	Eating.
Tshil-tshitl′-nuts ..	Lakes in Highland Valley.............	Slightly saline.
Tshi-m′mt-sim....	Blue Ravine	Washed out.
Tshi-poo-in..	Summit of pass near Chi′-poo-in M't'n..	A câche in the ground.
Tshi-wō′-us........	Mountain 3 miles north of Za-kwas′-ki..	
Tsho-ha-mous.	Cayoosh Creek..............	
Tshoo-loos′.......	Name applied to Guichon Creek........	
Tshoo-whēls′.....	Choo-whēls′ Mountain....	Many ravines.
Tshŭ-tshŭ.........	Murray Creek...........	

Indian Name.	Name Adopted or Description of Place on the Map.	Meaning Given for Indian Name.
Tsi′-kwus-tum	Câche Creek, lower part	Cracked rocks.
Tsil-tsālt	Tsil-tsālt Ridge	
Tsin-tsoon′-ko	Tsi-tsoon′-ko Lake	Island lake.
Tsoo-tsin-wowh	Lytton Mountains	Streams.
Tsoo-weh′	Texas Creek	The stream.
Tsot-in-ant-kwa	Tsotin Lake	Rattlesnake lake.
Tsuk-ă-tā′-tum	Forks of Tranquille River	Red place (earth?).
Tsuk-tsuk-kwālk′	Reservation on North Thompson	Red place (trees).
Tsuk-ōx	One of the Red Lakes	Red lake.
Tuk-a-mukēn′	At head of Criss Creek	Bare ground.
Tuk-too′-la-hum	Tuk-too′-la-hum Lake	Saline.
Wā-lia	Napier Lake	
Za-kwas-kī	Za-kwas′-kī Mountain	Dead.
Zlā′-lŏt	Black Hill Creek	Round prairie.

(2.) Names of Inhabited Villages on the Kamloops sheet.

Indian Name.	Name Adopted, or Description of Place on the Map.	Meaning Given for Indian Name.
Kam-a-loo′-la-pa	Kamloops	Point between the rivers.
Stlahl	Cornwall's	
Ne whuh-wait′-tin-e-kin	4 miles above Câche Creek	
Pu-kaist′	$1\frac{1}{3}$ mile above Pukaist Creek	White.
N'-kam-sheen	Spence's Bridge	
Tl-kam-sheen	Lytton	
Ni-kai′-a	Opposite Lytton	
Stā-ai′-in	Stein Creek	
Nes-ī-kip	Opposite Foster Bar	
Kan-lax′	Bridge River	The point.
Huh-ilp′	Fountain	On the edge.
Skwai′-luh	Pavilion Creek	Hoar-frost.
Kwē-kwē-a-kwēt′	11 miles above Kelley Creek	Blue.
Pil-tē′-uk	Clinton	White earth.
E-kuh-kah′-sha-tin	Pass Valley near Deadman River	Drying place.
Ski-shis-tin	Deadman River	
Sh-ha-ha-nih	Skuh′-un Creek	
N'-kah-li-mil-uh	Mouth of Upper Nicola River	
Spa′-ha-min	Douglas Lake	Scraped.
Tsuk-tsuk-kwālk′	North Thompson	Red place.

APPENDIX III.

NOTES ON THE UPPER AND LOWER LIMITS OF GROWTH OF SOME TREES AND OTHER PLANTS, IN DIFFERENT PLACES WITHIN THE AREA OF THE KAMLOOPS MAP-SHEET.

The subjoined observations are principally of interest in their bearings on the climatic features of the region to which they relate. In this connection reference may be made to pages 14 B, 15 B of the foregoing report.

PSEUDOTSUGA DOUGLASII (Douglas fir). Greatest heights at which this tree has been observed in various parts of the Kamloops sheet. *

	Feet.
East slope Cairn Mountain	5,750
South-east slope Mount Murray	5,750
Pass, Pavilion Creek to Maiden Creek	5,590
North of Za-kwaski	5,450
As-kom Mountain	5,430
East side Forge Mountain	5,350†
West slope Choo-whels	5,260
Head of Hat Creek (south slope)	5,220†
Arrowstone Hills	5,150
Cinder Hill (Highland Valley)	5,070†
South-west slope Lytton Mountains	4,860
North " " "	4,840
Pimainus Creek	4,780
Plateau, east of Deadman Lake (abundant)	4,500
East slope Botanie Mountains	4,220
Plateau east of Young Lake (abundant)	4,200

Though not abundant in the lower and drier valleys of the region the Douglas fir may be described as extending uninterruptedly down ward from the levels above given to the sea-level.

PINUS PONDEROSA (Yellow pine).—Greatest heights at which this tree has been observed in various parts of theKamloops sheet.—

	Feet.
North of Za-kwaski	5,300
Head of Hat Creek (south slope)	5,200
East slope Marble Mountains, north of Clinton Creek	5,100
Head of Maiden Creek	4,960
East slope Cairn Mountain	4,800
Clinton Creek	4,670

*Where marked †, it is not quite certain that the actually highest limit was observed.

	Feet.
North slope, Lytton Mountains	4,340
West of Clapperton Creek (east slope)	4,300
Pimainus Creek	4,190
North of Skuh'-un Creek (south slope)	4,170
South-west slope of Lytton Mountains	4,060
Highland Valley	4,000†
Hills above Leon Creek	3,930
La-loo-wissin Creek	3,830
Trail, Nicoamen to Nicola River	3,770
Hart Ridge (north slope)	3,530
Above Young Lake	3,500
Criss Creek	3,370

This pine is particularly characteristic of the lower and drier valleys and their slopes. It extends down the Fraser Valley about as far as North Bend Station (487 feet) and there ceases only because of the increasing moisture of the climate on approaching the coast.

Pinus Albicaulis, (White-barked pine). *Least* elevations at which this tree has been observed in the Kamloops sheet.—

	Feet.
East side Clear Mountains	5,750
East side Chi-pooin Mountain	5,610
Pass between La-loo-wissin and Hat Creeks	5,480
As-kom Mountain	5,400
Botanie	5,400
Lytton Mountains (north slope)	5,340
North slope Nicoamen Plateau	5,300
East end Nicoamen Plateau	5,170
Stein Mountain	5,000
Ascending Coast Range towards Kl-ow'-a Mountain	4,900
Prospect Creek (south part of Nicoamen Plateau)	4,450

From such heights as those above stated, this tree extends upward to the timber-line, but it is most abundant and characteristic between about 5500 and 6000 feet, in the region lying immediately to the eastward of the Coast Ranges, and characterized at such elevations by an alpine, but relatively dry climate. Within the limits of the Kamloops sheet, its geographical area may be thus defined :—To the west, bounded by a line following the higher summits of the Coast Ranges, to the east, by a line including Pavilion Mountains, following Hat Creek southward, including Mount Murray and thence following the Nicola Valley to the southern edge of the map. A very few specimens were, however, seen on the summits of Cornwall Hills to the east of this line.

Abies Subalpina, (Mountain fir). *Least* elevations at which this tree has been observed in the Kamloops sheet.

	Feet.
Pass between La-loo-wissin and Hat Creeks	5,480
Plateau above Jamieson Creek (abundant)	3,800
Botanie	3,660
Ascending Coast Ranges toward Kl-ow'-a Mountain	3,500

From such heights as those above stated, this tree extends upward to the timber-line, at about 7000 feet.

RHODODENDRON ALBIFLORUM. Least elevations at which this shrub has been observed in the Kamloops sheet.—

	Feet.
East end Nicoamen Plateau	5,170
Lytton Mountains (north slope)	5,140
Plateau, head of Jamieson Creek	4,800
Plateau, head of Skull Creek (in shade)	4,500
Ascending Coast Range towards Kl-ow'-a (in shade)	4,300

From such heights, this form extends upward nearly to the timber-line.

PINUS MURRAYANA (Black pine)—This tree occurs in greater or less abundance in all parts of the Kamloops sheet, and at all elevations up to the timber-line. It is, however, most characteristic of the plateaux at heights of 4000 or 5000 feet, where it frequently forms extensive forests. In the lower dry valleys it is scarce.

PICEA ENGELMANNI (Engelmann's spruce)—This tree is found nearly everywhere in the area of the Kamloops sheet, extending upwards to the timber-line, but is most characteristic of the higher plateaux and is seldom seen in the lower valleys.

TSUGA MERTENSIANA (Western hemlock)—This tree is very seldom found within the limits of the Kamloops sheet, where the climate appears not to be sufficiently humid for its healthy existence. It was observed at a height of 4000 feet in ascending the Coast Ranges, toward Poo-ytl Mountain, and is probably not uncommon at or above this height in the part of the Coast Ranges included by the map.

PINUS MONTICOLA (Western white-pine)—This tree also occurs very sparingly within the limits of the Kamloops sheet. It was observed at a height of 4200 feet in ascending the Coast Ranges towards Poo-ytl Mountain.

THUYA GIGANTEA (Western cedar)—This tree was observed in a few places within the limits of the map, but never attaining a large size It is confined usually to narrow and shaded valleys, where considerable moisture is to be found. It was noted on the North Thompson

above the Fish-trap Rapid, on Edwards Creek, near the eastern limit of the map, at Botanie and near the east end of the Nicoamen Plateau a little beyond the south edge of the map.

Ledum Glandulosum.—Found on the plateau near the head of Skull Creek, at an elevation of 4500 feet, on the plateau near the Middle Fork of Tranquille River, at a similar elevation, and on the plateau near Spaist Mountain, between 4500 and 5000 feet.

Pachystema Myrsinites was observed to be abundant on Botanie Mountain, on the Lytton Mountains, and on the eastern part of the Nicoamen Plateau, but not elsewhere within the limits of the sheet.

Evernia Vulpina.—This bright yellow lichen, growing upon trees, is generally abundant at heights exceeding 3000 feet, but it was observed in abundance at exceptionally low elevations in the Twaal Valley (2740 feet) and in the Venable Valley (2230 feet).

APPENDIX IV.

Comparative Observations of Temperatures at different Altitudes in or near the Region embraced by the Kamloops Sheet, Southern Interior of British Columbia, during parts of the Years 1888, 1889 and 1890.

Table I.—A summary of minimum temperatures grouped according to altitudes and compared with the minima observed during the same nights at Kamloops.

Table II.—Temperatures observed at 9 p.m. at various altitudes, compared with simultaneous observation at Kamloops.

Note.—In the column headed "Difference" + means higher and − lower than at Kamloops. The height of Kamloops above the sea is 1150 feet. In the pages following the tables, the observations are given in detail, with the actual elevation and locality of each.

The observations made at 9 p.m., appear to show that, soon after sunset, the effect of nocturnal radiation in lowering the temperature increases almost uniformly to the greatest heights represented. The minimum temperatures likewise show a nearly regular decrease with increased height, up to between 4000 and 5000 feet, beyond which, for 2000 feet or more (to the greatest heights represented) this ceases, and the difference as compared with Kamloops remains nearly constant.

As compared with the normal vertical temperature gradient of the atmosphere (1° F. to 300 feet) the minima are some 5° too low at about 4500 feet and nearly 3° too high at 6500 feet. This anomaly may be explained by the existence of considerable areas of plateau country up to nearly 5000 feet, while the areas standing above 5000 feet are relatively small. It may also be connected with the general inflow of air from the west, across the Coast Ranges, maintaining a nearly constant temperature when little in contact with radiating land surfaces. Mr. R. F. Stupart, Director of the Meteorological Service, informs me that such an inflow, during the summer months, is indicated by the mean barometric gradients and that the years 1889 and 1890 were nearly normal in this respect.

TAB

TEMPERATURE IN RELA

MINIMUM Temperatures observed at various altitudes, compared with

Month and Year.	Altitudes under 1000′.				Altitudes 1000′-2000′.				Altitudes 2000′-3000′.				Altitud	
	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.
1888.		°	°	°		°	°	°		°	°	°		°
July......	1	49	52·2	−3·2	..	......	......	......	4	38·2	56·5	−18·3	12	35·6
1889.														
July......	.	......	......	......	4	55·5	61·77	− 6·27	13	47·4	57·4	−10	4	43·1
Aug......	..	......	......	......	2	39·7	52·1	−12·4	6	47	56·7	− 9·7	5	45·5
Sept.	6	41·8	39·9	+1·9	7	48·8	47	+ 1·8	1	43	43·9	− 0·9	7	35
Oct .. .	1	49	41·9	+7·1	2	40·5	43·4	− 2·9	3	30·7	39	− 8·3	16	32·7
1890.														
June.....	..	......	......	...	..	......	......	......	1	43·5	50·3	− 6·8	4	38·1
July......	2	52·5	51·95	+0·55	1	50	54	− 4	2	45	56·85	−11·85	1	36
Aug......	..	......	......	......	4	41·3	53·0	−11·7	2	48·5	59·65	−11·15	..	......
Sept.	..	......	......	......	7	39·8	42·5	− 2·7	5	35·1	42·84	− 7·74	8	36
Oct.......	..	......	....	......	5	41·2	40·7	+ 0·5	1	42	45·2	− 3·2	..	......
	10	45·38	38·54	+6·84	32	44·49	47·87	− 3·38	38	43·02	53·08	−10·06	57	6·35

LE I.

TION TO ALTITUDE.

the minima observed during the same nights at Kamloops, B.C.

es 3000′-4000′.		Altitudes 4000′-5000′.				Altitudes 5000′-6000′.				Altitudes 6000′-7000′.			
Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.
°	°		°	°	°		°	°	°		°	°	°
54·4	−15·8	...	......	......	.....	3	35·6	51·4	−15·8	1	39	49	−10
55·1	−12	1	31	55	−24	1	43	51	− 8	..	.....	.....	.....
54·25	− 8·75	6	34	54·4	−20·4	1	31	49	−18	3	33·5	52·1	−18·6
45·7	−10·7	1	41	50·6	− 9·6	1	34	51·5	−17·5	1	34	47	−13
44·2	−11·5	3	33·1	50·1	−17	..	.....	......	.....	..	......	.....	......
56·7	−18·6	5	28·6	49·5	−20·9	1	31	48·5	−17·5	..	.....	.....	.....
54·8	−18·8	1	48	62	−14	5	37·5	52·7	−15·2	2	36·5	49·7	−13·2
.....	......	3	39·3	55·2	−15·9	2	34·5	52·9	−18·4	..	.....	.....	.....
50·15	−14·15	2	29	41·2	−12·2	1	28	46	−18	..	.....	.....	.....
.....	......	..	......	......	.....	..	......	......	.....	..	.....	......	.....
50·08	−13·73	22	33·77	51·85	−18·08	15	36·0	51·3	−15·3	7	35·2	50·2	−15·0

TAB

TEMPERATURE IN RELA

TEMPERATURES observed at 9 p.m. at various altitudes, compared

Month and Year.	Altitudes under 1000′. No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	Altitudes 1000′-2000′. No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	Altitudes 2000′-3000′. No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	Altitud No. of observations.	Mean.
1889.		°	°	°		°	°	°		°	°	°		°
July......	..	......	......	......	3	69	79·1	−10·1	14	62·8	80·5	−17·7	4	56·2
August...	..	......	....	......	2	67·5	68·8	− 1·3	5	59·6	70·7	−11·1	5	54·2
Sept......	6	50·8	49·5	+1·3	7	60	60·3	− 0·3	1	55	61·9	− 6·9	6	40·4
Oct	1	55	59·2	−4·2	2	48·5	51·5	− 3	3	38	42·4	− 4·4	14	40·5
1890. June......	..	......	......	......	1	64	73	− 9	..	......	......	......	4	50·6
July......	1	59	58·9	+0·1	..	......	......	......	1	68	79·1	−11·1	..	....
Aug.	..	......	......	....	5	59·4	66·4	− 7	1	56	70·7	−14·7	..	.....
Sept......	..	......	......	......	9	51·5	56·5	− 4	5	49·8	59·7	− 9·9	7	44·1
Oct	..	......	......		3	48	47·5	+ 0·5	1	46·5	49·3	− 2·8	..	.....
	8	52·35	51·9	+0·45	32	57·1	61·0	− 3·9	31	64	69·9	− 5·9	40	45·4

LE II.

TION TO ALTITUDE.

with the observations made at the same time at Kamloops, B.C.

es 3000′-4000′.		Altitudes 4000′-5000′.				Altitudes 5000′-6000′.				Altitudes 6000′-7000′.			
Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.	No. of observations.	Mean.	Corresponding mean at Kamloops.	Difference.
°	°		°	°	°		°	°	°		°	°	°
65·8	--19.6	..	.....	.....	.....	..	.....	.....	....	..	.....	.....	.....
67·3	- 9.5	7	46·3	66·5	-20·2	1	45	63·3	-18·3	3	37·8	60·9	-23·1
51·3	-10·9	1	49	58·5	- 9·5	1	44	59	-15	2	41·5	60·3	-18·8
46·4	- 5·9	3	43·3	54·6	-11·3	..	.....	.....	.....	.	.....	.....	.....
67·8	-17·2	5	42·1	60·9	-18·8	..	.....	.....	.....	..	.....	.....	.....
.....	.....	1	46	72	-26	4	39·2	58·7	-19·5	2	43·5	62·5	-19
.....	.....	3	46·7	62·3	-15·6	2	42	68·1	-26·1	..	.....	.....	.....
59·2	-15·1	2	40·5	53·1	-12·6	1	45	58·8	-13·8	..	.....	.....	.....
.....	.....	..	.....	.....	.....	..	.....	.....	.....	..	.....	.....	.....
56·57	-11·17	22	44·57	61·7	-17·13	9	41·6	61·3	-19·7	7	40·5	61	-20·5

TEMPERATURE OBSERVATIONS.*

Date.	Altitude.	Minimum temperature.	Corresponding Minimum at Kamloops.	Difference.	——	Locality.
1888.	Ft.	°	°	°	°	
July 4	3920	41	50	− 9	....	Head of Guichon Creek.
" 5	3920	40	51	−11	....	" "
" 6	3300	31	47·4	−16·4	....	Mamit Lake.
" 7	3300	33·5	49·3	−15·8	....	"
" 8	3470	33·5	52·5	−19	Max., 86·5	Witches Brook.
" 9	3470	40	56·3	−16·3	....	"
" 10	3870	30	56	−26	....	Highland Valley.
" 11	900	49	52·2	− 3·2	....	Mouth of Pimainus Creek.
" 14	2690	35	52	−17	....	Skuh-un' Creek.
" 15	3150	30	52·6	−22·6	Max., 75	Guichon Creek.
" 16	3150	37·5	59·6	−22·1	....	"
" 19	3500	52	59	− 7	....	Prospect Creek.
" 22	3100	28·5	58·5	−30	Max., 92·5	Head of Otter River.
" 23	3100	31	62	−31	....	" "
" 24	2530	39	58·9	−19·9	....	Otter Flat (Campment des Femmes)
" 25	2440	39	57·1	−18·1	....	Opposite Granite Creek.
" 26	2530	40	58·2	−18·2	....	Otter Flat.
" 27	5400	35·5	47	−11·5	....	Old Brigade Trail.
" 29	5200	40	59·8	−19·8	....	Near Upper Tulameen.
" 30	5200	31·5	47·5	−16	....	" "
" 31	6200	39	49	−10	....	Near Loadstone Mountain.
Aug. 1	2860	51	......	......	....	Rabbit's Store, Tulameen.

*Altitude of Kamloops, 1150 feet.

TEMPERATURE OBSERVATIONS.*

Date.	Altitude.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature.		Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1889.	Ft.	°	°	°	a.m.	°	°	°	°		
July 1	3070	42	50·7	− 8·7	6	47	53	67	−14	....	Loon Lake camp.
" 2	2180	39	51·5	−12·5	7.15	59	56	72·3	−16·3	....	Deadman River.
" 3	2180	44	55·9	−11·9	6	51	68	78·9	−10·9	....	"
" 4	2520	42	53·5	−11·5	6	60	....	....	....	....	Tsotin Lake.
" 5	1130	52	52	0	8	55	56	58·9	− 2·9	....	Savona.
" 6	2410	....	47·9	....	7	52	50	66·9	−16·9	....	South of Penny's.
" 7	3974	44	57	−13	p.m. 2	74	52	61·9	− 9·9	Max., 74°	Slope of Mt. Glossy.
" 8	3974	39	50·2	−11·2	a.m. 6.30	40	.....	....	....	....	"
" 9	5550	43	51	− 8	6	44	56	70	−14	....	Mt. Glossy.
" 10	2300	50	55	− 5	7.15	64	.....	....	....	....	South of Penny's.

*NOTE.—The minimum temperature and the morning observation in each case correspond with the altitude given in the same line of the table. The evening observation, however, corresponds with the altitude given in the next line below, the camp having been moved in the course of the day.

TEMPERATURE OBSERVATIONS—*Continued.*

Date.	Altitude.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature.		Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1889.	Ft.	°	°	°	a.m.	°	°	°	°		
July 11	....	.....	58·5	.....	.....	.....	63	73·9	−10·9	.....	Kamloops Lake.
" 12	2130	52	56	− 4	6.20	56	45	78	−33	.....	Duffy Creek.
" 13	4130	31	55	−24	6.20	40	.....	.....	.....	.....	Upper Cherry Bluff Creek.
" 15	....	.....	.....	.....	.....	.....	63	77·5	−14·5	.....	Kamloops.
" 16	1850	55	66·9	−11·9	6.15	70	60	66·5	− 6·5	.....	Reservation Creek.
" 17	2890	49	60·7	−11·7	6.15	59	59	76	−17	.....	Edwards Lake.
" 18	2950	50	60·1	−10·1	6	51·5	70	80	−10	.....	Head of Louis Creek.
" 19	1240	.....	.....	.....	8	78	74	79·9	− 5·9	.....	Near Pemberton's Ranch.
" 20	1240	60	65·7	− 5·7	6.30	66	61	73	−12	.....	" "
" 21	2500	45	54·5	− 9·5	8	69	84	73	+11	.....	Near South Thompson.
" 22	2500	44	53·8	− 9·8	8	54	.....	.....	.....	.....	" "
" 25	1990	55	62·5	− 7·5	6	60·5	68	80·9	−12·9	.....	Campbell Creek.

" 26	2220	53	64·1	−11·1	6	59	54	79	−25	....	Newman's.
" 27	3700	47·5	62·7	−15·2	5.45	49	60	81	−21	....	West of Brigade Lake.
" 28	2480	44·5	61·6	−17·1	7.10	64	69	80·3	−11·3	....	Dropping-water Creek.
" 29	2300	57	62·4	− 5·4	8.30	69	69	75·6	− 6·6	Noon, 82°.	Scott Creek.
" 30	3542	....	61	....	8	61	66·5	77·9	− 9·4	11.30, 85°.	Douglas Plateau.
" 31	2630	47·5	57·9	−10·4	6	52	58	74	−16	....	Above Douglas Lake.
Aug. 1	2020	44	54·8	−10·8	7	52	64	68·5	− 4·5	....	Nicola Lake.
" 2	2020	49	55·9	− 6·9	6	51	68	78·9	−10·9	....	Quilchenna.
" 3	2020	52	58·6	− 6·6	6.45	60	65	....	....	....	Clapperton's.
" 4	2100	46·5	59	−12·5	8	58	58	66·2	− 8·2	....	Guichon Creek.
" 5	2100	45·5	59·1	−13·6	6.30	54	65	64·8	+ ·2	....	"
" 6	1700	35	50	−15	8	59	55	66·4	−11·4	....	Nicola River.
" 7	3120	46	56	−10	7	49	45	63·3	−18·3	....	Trail to Za-kwaski Mt.
" 8	5560	31	49	−18	6.50	44	41	67·3	−26·3	....	"
" 9	6180	35	51·1	−16·1	8.15	65	44	....	....	....	Za-kwaski camp.
" 10	6180	44	....	....	7	52	60	65·9	− 5·9	....	"
" 11	3350	48	51·9	− 3·9	7	54	70	72·8	− 2·8	....	Near Agate Creek.
" 12	1400	44·5	54·4	− 9·9	6.30	59	55	73·4	−18·4	....	Nicola River.
" 13	4800	31·5	57·1	−25·6	8	61	44	73	−29	....	Pimainus Lake.
" 18	....	....	....	....	....	....	46	56·3	−10·3	....	Botanie.

TEMPERATURE OBSERVATIONS—*Continued.*

Date.	Altitude.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature,		Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1889.	Ft.	°	°	°	a.m.	°	°	°	°		
Aug. 19	3610	43	52·5	− 9·5	7.45	46	50	66·3	−16 3	....	Botanie.
" 20	2940	45	53	− 8	8	48	.....	....	....	....	Skoon-ko' Creek.
" 21	790	....	51·7	....	....		59	79·1	−20·1	....	Spence's Bridge.
" 22	3190	50	52·9	− 2·9	7	53	53	73·9	−20·9	....	Murray Creek.
" 23	4510	35	54	−19	9	49	39	55·8	−16·8	....	Murray Mountain camp.
" 24	4510	32	48	−16	8	39	45	64·8	−19·8	....	" "
" 25	4510	36	54·5	−18·5	....		45	66·9	−21·9	....	" "
" 26	4800	33	57·5	−24·5	6.45	39	43	58·2	−15·2	....	Head of Hat Creek.
" 27	4480	37	55·9	−18·9	7.40	45	33·5	55·2	−21·7	....	Blue-earth Creek.
" 28	6610	28·5	50·2	−21·7	7.45	33·5	39	60·4	−21·4	....	Cairn Mountain camp.
" 29	6610	37	55	−18	7	43	51	70	−19	....	Hat Creek.
" 30	3470	40·5	57·9	−17·4	7	45	.....	....	....	....	

Sept. 2							39	52	-13		Cornwall's.
" 3	3480	27	43·9	-16·9	7.30	38	44	48·9	- 4·9		McLean Lake.
" 4	3080	31	39·4	- 8·4	7.45	45	54	64	-10	Max., 71°.	Medicine Creek.
" 5	3080	51	56·4	- 5·4							"
" 6	3080	39	51·5	-12·5	7	49	43	61·6	-18·6		"
" 7	6220	34	47	- 13	7.30	41	40	59·1	-19·1		Chi-pooin camp.
" 8	6220	30 (?)	44·9	-14·9	7.40	28	8.45 p. 33·5	45·3	-12·3		"
" 9	3120	31	38	- 7	8	33	9 p. 35	44·3	- 9·3		Three-lake Valley.
" 10	3120	29·5	40·9	-11·4	7·25	32	50	44·6	+ 5·4		" "
" 11	800	40·5	40·1	+ ·4	7·40	43·5	50·5				Rock-slide camp.
" 12	640	42	40·5	+ 1·5	7.40	47	41	40·9	+ ·1		Lillooet camp.
" 13	640	34	36	- 2	8	40	53·5	45	+ 9·5		"
" 14	780	48·5	39·8	+ 8 7	8	49					Bridge River.
" 15	780						59	55·1	+ 3·9		"
" 16	780						51	62·1	-11·1		"
" 17	940	46	46·5	- ·5	7	52	64	66·1	- 2·1		Spring camp opposite Fountain.
" 18	1740	52	50	+ 2	7	56	70	65·1	+ 4·9		Opposite Pavilion Creek.
" 19	1250	60	46·2	+13·8	7.10	60	68	60·3	+ 7·7		Above Leon Creek.
" 20	1540	52	45·5	+ 6·5	7	53	56	63·6	- 7·6		Camp above Watson Creek.
" 21	1086	46·5	52	- 5·5	8	51·5	55	57·7	- 2·7		Leon Creek.

TEMPERATURE OBSERVATIONS—*Continued.*

Date.	Altitude.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature.	Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1889.	Ft.	°	°	°	a.m. °	°	°	°		
Sept. 22	1740	43	49·3	- 6·3	{ 8·15 52 } { 2 p. 59 }	52	51·7	+ ·3	Max., 64°.	Opposite Pavilion Creek.
" 23	1740	44	45	- 1	7.15 a. 50·5	46	49·3	- 3·3	....	" "
" 24	700	40	36·8	+ 3·2	a.m. 7 44	8.45 p. 50	....	....	....	1 mile below Bridge R.
" 25	1077	40·5 at 6.25 a.	38·4	....	7.20 40·5	9 p. 55	57·7	- 2·7	....	Fountain Creek.
" 26	1640	44	41	+ 3	7.25 45·5	55	61·9	- 6·9	....	18-Mile Creek.
" 27	2300	43	43·9	- ·9	7.20 49	49	58·5	- 9·5	....	Pavilion Creek crossing.
" 28	4390	41	50·6	- 9·6	7.10 47·5	44	59	-15	....	Upper Pavilion Creek.
" 29	5480	34	51·5	-17·5	7.30 36	37	57·1	-20·1	....	Pavilion Mountains.
" 30	3120	37	49·9	-12·9	7.40 43	36	51	-15	....	Glen Hart.
Oct. 1	3120	33	59	-26	8 35	36	....	....	....	"
" 2	3090	30	47	-17	8 41	42	56	-14	....	Clinton.
" 3	3600	....	.. ...	....	8 45	40	53	-13	2 p., 50°...	Kelley Lake camp.

" 4	3600	31·5	57	-25·5	7.40	41	55	59·2	- 4·2		" "
" 5	940	49	41·9	+ 7·1	7.40	49·5	56	60·8	- 4·8		Camp opposite Leon Creek.
" 6	1720	50	47·8	+ 2·2	7.45	54	51	58·3	- 7·3		Cascade camp.
" 7	3360	35	46	-11	8	40	46	56·2	-10·2		Haller's Mill.
" 8	4620	33	52·9	-19·9	7.40	34	42				Head of Kelley Creek.
" 9	3600	38	49·3	-11·3	7.10	39					Kelley Lake camp.
" 10	3090	41	49·3	- 8.3	9	42·5	39	50·4	-11·4		Clinton.
" 11	3090	38	43	- 5	8	42	36·5	52·4	- 5·9		"
" 12	4850	35	49·9	-14·9	7.45	40	47·5	55·3	- 7·8		Head Clinton Creek.
" 13	4160	31·5	47·5	-16	7.15	33	52	53·3	- 1·3		Head Sandy Creek.
" 14	3660	33	45	-12	8	34	28	45·8	-17·8	Max., 45°	Big Bar Lake.
" 15	3660	20	32·9	- 12·9	8	23	30	42	-12		"
" 16	3800	21	33·5	-12·5	8	32	8.45 p. 35·5	43	- 7·5		Boyd's 70-Mile House.
" 17	3860	26·5	38	-11·5	7.30	32	8.30 p. 36	40	- 4		Green Lake.
" 18	2960	27	35·5	- 8·5	7.30	30	9 p. 34	40·4	- 6·4		Bonaparte River.
" 19	2340	28	34	- 6	7.30	30	37	43	- 6		" "
" 20	3120	31	39·5	- 8·5	8	34	41	42·3	- 1·3		Glen Hart.
" 21	1800	31	39	- 8	7.30	41	44	47	- 3		Bonaparte at Hat Creek.
" 22	2600	37	47·4	-10·4	7·30	42	44	48·9	- 4·9		Tsotin Lake.
" 23	3515	42	47·9	- 5·9	7·30	43	8.40 p. 39	50·9	-11·9		Summit camp.

TEMPERATURE OBSERVATIONS—*Continued.*

Date.	Altitude.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature.		Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1889.	Ft.	°	°	°	a.m.	°	°	°	°		
Oct. 24	3200	37	43·2	- 6·2	7.20	41	40	46·6	- 6·6	....	Upper Tranquille R.
" 25	3500	33	36·2	- 3·2	8	40	8.40 p. 44	47·2	- 3·2	....	Middle Fork Tranquille.
" 26	3500	33·5	40·6	- 7·1	7	34	9 p. ..	....	....	....	" "
1890.											
June 19	2780	43·5	50·3	- 6·8	6	51	35	57·6	- 22·6	....	Jacko Creek.
" 20	4100	26·5	45	- 18·5	6.30	39	......	....	....	....	Trout Lake.
" 21	5850	31·5	49	- 17·5	.....	.....	9.25 p. 38	59·3	- 21·3	....	Choo-whels Mountain.
" 22	4890	25	48·6	- 23·6	7	42	9 p. 51	67·8	- 16·8	2 p.m., 67°.	Face Lake.
" 23	4100	35·5	53·5	- 18	8.40	44·5	43	58·7	- 15·7	....	Meadow Creek.
" 24	4100	28	52·5	- 24·5	.....	.....	43·5	61	- 17·5	Max., 66°.	"
" 25	4100	28	48	- 20	.....	.....	50·5	65	- 14·5	....	"
" 26	3480	34	53·5	- 19·5	7.10	51	9.15 p. 48	63	- 15	....	Witches Brook.
" 27	3450	35	53·4	- 18·4	.....	.....	9 p. 52	70·9	- 18·9	....	"

" 28	3800	38·5	59 7	-21·2	12.30	75	52	72·5	-20·5		Mo. Woods Creek.
" 29	3800	45	60·5	-15·5							Near Pukaist Creek.
" 30							64	73	- 9		Twaal Creek crossing.
July 1	1700	50	54	- 4							"
" 2							68	79·1	-11·1		Head Twaal Creek.
" 3	2230	51	62·8	-11·8			9.20 p. 46 9 p.	72	-26		Venable Valley.
" 4	4070	48	62	-14	7	51					Bear Spring.
" 5	3600	36	54·8	-18·8							Botanie.
" 6	2880									Max., 59°.	Botanie Creek.
" 7	2880	39	50·9	-11·9			59	58·9	+ ·1		"
" 8	500	53	50	+ 3			39	62	-23		Lytton.
" 9	5880	35	53·5	-18·5			39	54·9	-15·9	Max., 49°.	Lytton Mountains.
" 10	5880	35	50·9	-15·9	8	37	39	61	-22	2.40 p., 40·5°.	"
" 11	5880				8	50	40	57	-17	Max., 58°.	"
" 12	5880	36	52·5	-16·5							
" 16	5930	40	50·9	-10·9							Kl-ow'a Mountain camp.
" 17	5930	40·5	54·6	-14·1							" "
" 19							42	59·9	-17·9		Stein Mt.
" 20	6680	34	47·9	-13·9			45	65·2	-20·2		"
" 21	6680	39	51·6	- 12·6							"

TEMPERATURE OBSERVATIONS—*Continued.*

Date.	Altitude.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature.	Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1890.	Ft.	°	°	°	a.m. °	°	°	°		
July 22									Max., 97°.	Stein Creek.
" 23	550	52	53·9	- 1·9						"
" 27						59	53·9	+ 5·9		Texas Creek.
Aug. 1	2400	51	60·2	- 9·2						Pavilion Creek.
" 2	1600					69	71·9	- 2·9		Bonaparte River.
" 3	1600	49	59·3	-10·3						"
" 6						61	64·9	- 3·9		Deadman River.
" 15						60	63·5	- 3·5		Fish-trap Rapid.
" 16	1200	40	47	- 7		55	64·3	- 9·3		"
" 17	1200	42	55·9	-13·9		52	67·6	-15·6		Barrière River.
" 18	1200	34·5	50	-15·5						Opposite Indian Reserve.
" 21	4070					46	62·5	-16·5		Eating Lake.

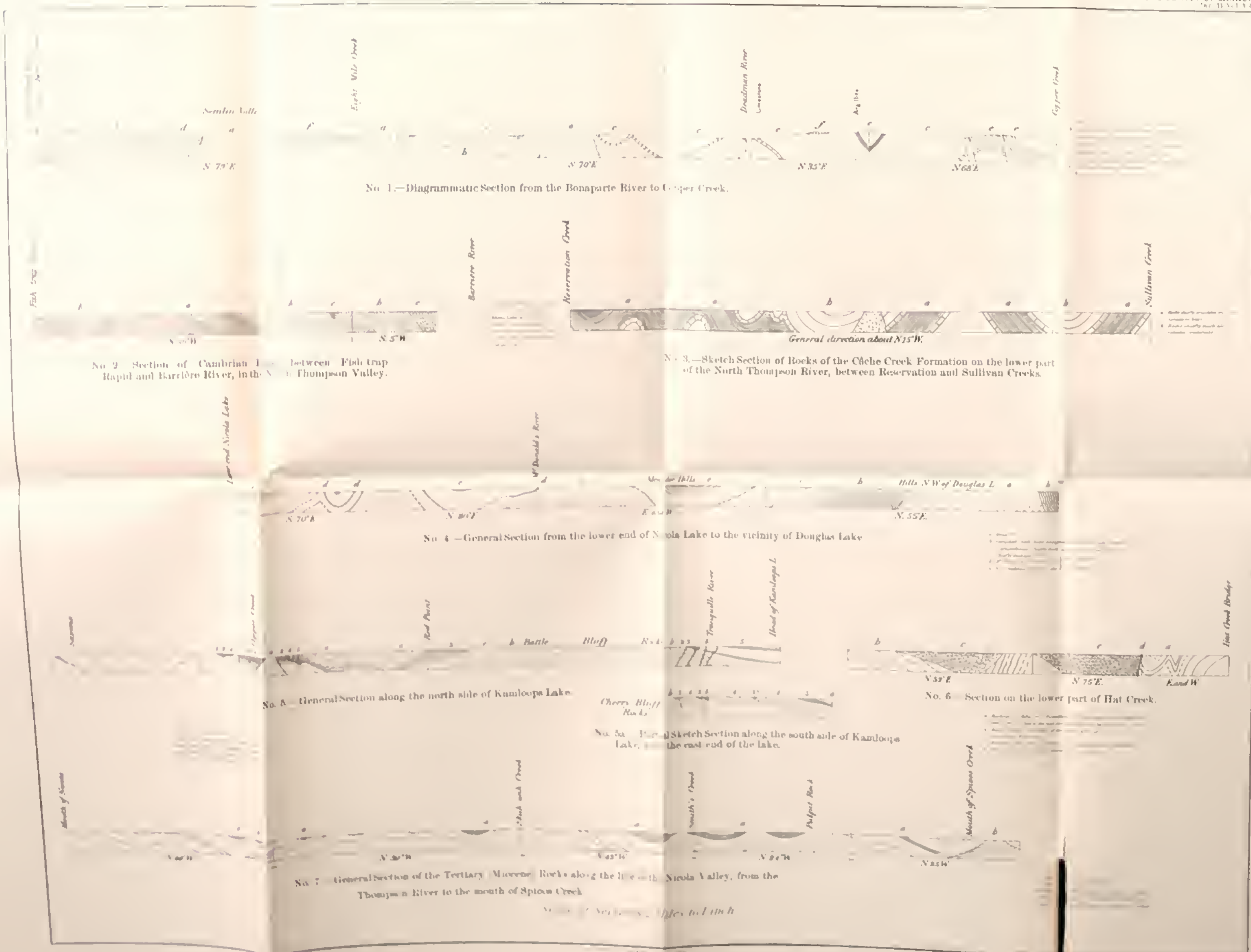
"	22	4070	34	53	- 19	....	45	58	- 13	....	"
"	23	4500	41	53	- 12	....	49	66·3	- 17·3	....	West of Sku Hill.
"	24	4900	43	59·6	- 16·6	....	....	....	....	....	Near Poison Hil
"	25	5100	36	58·1	- 22·1	....	44	70	- 26	....	Poison Hill camp.
"	26	5480	29	....	....	7.20 44	8.50 p. 40	66·2	- 26·2	Noon, 65°.	Caribou Lake.
"	27	5920	33	47·8	- 14·8	....	9 p. 52	63	11	....	Porcupine Ridge.
	28	....	....	....	....	....	56	70·7	- 14·7	....	"
"	29	2900	46	59·1	- 13·1	....	....	....	....	....	Lake LeBois.
Sept.	1	2600	....	....	....	....	50	53·3	- 3·3	....	Peterson Creek.
"	2	3500	....	....	....	....	43	53·4	- 10·4	....	West of Brigade Lake.
"	3	3500	39	49·5	- 10·5	....	45	63	- 18	....	" "
"	4	....	....	....	....	....	45	60·9	- 15·9	....	Head of Moore Creek.
"	5	3480	40	51·9	- 11·9	....	39	57	- 18	....	" "
"	6	2890	25	38·6	- 13·6	....	Scotts 48	53	- 5	....	Moore Creek.
"	7	....	....	....	....	....	53	62·3	9·3	....	Scott Creek.
"	8	2020	33	47·2	- 14·2	....	50	65·6	- 15·6	....	Nicola Lake.
"	9	2600	33·5	41·9	- 8·4	....	....	....	....	....	Douglas Lake.
"	10	3020	40	48·8	- 8·8	....	8.40 p. 35	50·9	- 15·9	....	Chaperon Lake.
"	11	3020	21	33·5	- 12·5	....	9 p. 31	44·6	- 13·6	....	"
"	12	4200	17	31·5	- 14·5	7.15 26	45	58·8	- 13·8	....	South-east Chaperon Lake.

TEMPERATURE OBSERVATIONS—*Concluded.*

Date.	Altitudes.	Minimum temperature.	Corresponding minimum at Kamloops.	Difference.	Time and Temperature.	Temperature at 9 p.m.	Corresponding temperature at Kamloops.	Difference.	—	Locality of minimum and morning reading.
1890.	Ft.	°		°	a.m °	°	°	°		
Sept. 13	5680	28	46	-18	7.45 42	50	61·7	-11·7	....	Okanagan Plateau.
" 14	4580	41	50·9	- 9·9	....	59	61	- 2	....	"
" 15	2330	41	44·5	- 3·5	....	54	58·9	- 4·9	....	Deep Creek.
" 16	1250	53	47·2	+ 5·8	....	60	57·5	+ 2·5	....	Okanagan Lake.
" 17	1250	54	47	+ 7·0	....	54	55	- 1	....	"
" 18	1250	36	36·8	- ·8	....	59	49·6	+ 9·4	....	
" 19	1250	39	40	- 1·0	....	49	55·9	- 6·9	....	O'Keefe's.
" 20	1250	37	45	- 8·0	8 57	8.30 p. 49	60·3	-11·3	....	Vernon.
" 21	......	....	......	....	....	9 p. 49	....	......	....	Coldstream.
" 22	1550	42·5	......	....	7.15 48	45	59·3	-14·3	....	"
" 23	1680	28	41·4	-13·4	....	8.15 p. 48	54·3	- 6·3	....	Near Slack's.
" 24	1460	32	40·2	- 8·2	7.30 47	......	....	....	....	Shingle camp.

"	25	2480	43	42	+ 1	7.30	48	......	......	......	......	Cherry Creek Mines.
"	26	3860	35	47	- 12	7.15	37	8.40 p. 43	63·1	- 20·1	......	McIntyre's.
"	27	3860	37	51	- 14	8.15	42	8.20 p. 48	69·8	- 21·8	......	"
"	28	3860	39	63·5	- 24·5	......		8.30 p. 49	......	......	......	"
"	29	3860	36	55	- 19	......		8.45 p. 45·5	58·9	- 13·4	......	"
"	30	1680	......	......	......	7.30	54	8.30 p. 46	46·9	- ·9	......	Tom Slack's.
Oct.	1	1630	37	41·6	- 4·6	......		......	......	......	......	Coldstream.
"	2	1300	44	35·8	+ 8·2	......		9 p. 51	46·6	+ 4·4	......	Long Lake.
"	3	1300	48	39	+ 9	......		......	......	......	......	"
"	4	1300	36	42	- 6	8.15	43	47	48·9	- 1·9	......	Vernon.
"	5	1460	42	44·9	- 2·9	8	44	44	......	......	......	Salmon River.
"	6	1900	41	......	......	8	46	46·5	49·3	- 2·8	Noon, 51°.	Grande Prairie.
"	7	2200	42	45·2	- 3·2	......		......	......	......	......	Near Monte Lake.

GEOLOGICAL SURVEY OF CANADA



KAMLOOPS SHEET B.C. SECTIONS

GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

REPORT

ON AN EXPLORATION

OF THE

FINLAY AND OMENICA RIVERS

BY

R. G. McCONNELL, B.A.

OTTAWA
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EXCELLENT MAJESTY
1896

GEORGE M. DAWSON, C.M.G., LL.D., F.R.S.,

Director of the Geological Survey of Canada.

SIR,—I beg to present herewith a report, accompanied by a map, on the Omenica and Finlay Rivers, based on field-work carried out by myself, and by Mr. H. Y. Russel who acted as my assistant, during the season of 1893.

I have the honour to be, sir,

Your obedient servant,

R. G. McCONNELL.

Geological Survey Office, 30th Nov., 1895.

NOTE.—*The bearings given in this report are all referred to the true Meridian.*

REPORT

ON AN EXPLORATION OF THE

FINLAY AND OMENICA RIVERS

BY

R. G. McCONNELL, B.A.

The following report on the Omenica and Finlay rivers is based on an exploration carried out during the year 1893. Quesnel, on the Fraser, was selected as the base of operations. That point was reached on the 24th of May, but owing to the scarcity of competent canoemen, and to delays in obtaining transport for supplies to Fort McLeod, we were detained there until the 9th of June. The party consisted, besides myself, of Mr. H. Y. Russel, who acted as topographer, and four canoemen (two Indians, one half-breed, and one white man). From Quesnel we proceeded up the Fraser River to the Giscome Portage, where we arrived on the 23rd of June. A portage-road here, seven miles and a half in length, connects the Fraser River with Summit Lake, one of the sources of Peace River. The portage was made in two days and a half. From Summit Lake we followed a chain of small lakes connected by small, crooked, and at times exceedingly swift streams down to Fort McLeod, which we reached on the 28th of June. Our supplies, which had been sent overland by pack-train from Quesnel, were delayed owing to the flooded condition of the rivers, and did not arrive until a week later. On the 6th of July we started down McLeod Lake River and the Parsnip, carrying our summer's supplies, in two Peterborough canoes, and a canvas canoe which we had fitted up while waiting at Fort McLeod. The mouth of the Parsnip, our objective point, was reached on the following day.*

Preparations for the journey.

Route followed.

The Parsnip, coming from the south, and the Finlay from the northwest, meet near the western base of the Rocky Mountains, and the united streams, bending to the east, break through that range and traverse the great central plain of the continent in a northerly direction under the various names of Peace, Slave and Mackenzie rivers.

*The route followed from Giscome Portage to the mouth of the Parsnip, was examined by Dr. A. R. C. Selwyn in 1875, and is described by him in the report of the Geological Survey for that year, pp. 37-41 and 64-67.

Rivers explored.

Peace River was descended as far as the foot-hills bordering the Rocky Mountains on the east, and a hasty examination of the structure of the range and of its various geological components was made. After returning to the Parsnip-Finlay Forks, the latter stream was ascended to the mouth of the Omenica, the first considerable tributary which it receives. An ascent of the Omenica was then made to a point above the Omenica-Sitleka Pass. On the way up visits were made to the Germansen Creek, Manson Creek, and other old gold mining camps of the region, all now nearly abandoned. A traverse was also made of one of the passes leading from the Omenica River to Tacla Lake.

The examination of the Omenica River occupied about three weeks. After completing, it we returned to our câche which we had previously constructed at its mouth, and on the 5th of August commenced the ascent of the main branch of the Finlay. Fort Grahame was reached on the 8th, the forks, or the junction of the Qua-da-cha (white water) with the Finlay, on the 21st, and the Fishing Lakes above the long series of rapids at the "Bend," on the 28th of August. The latter part of the journey was made on foot, owing to the almost unnavigable condition of the river.

A couple of days were spent in climbing the mountains in the vicinity of the Fishing Lakes, after which the return journey was commenced. The mouth of the Finlay was reached on the 14th of September and Quesnel on the 1st of October.

Character of exploration.

The exploration was necessarily carried out in a somewhat hurried manner, owing to the shortness of the season available for work, and the time occupied in making the long journey from Quesnel to the field of operations. About nine weeks in all were spent on the Finlay and its branches, but as considerable time was lost in making return trips over the same routes, and on account of bad weather, barely six weeks were left for effective work.

Mountainous nature of country.

The region drained by the Finlay and its branches is characterized throughout by its mountainous character; with the exception of the narrow flats bordering the principal rivers, no plains of any magnitude were anywhere observed. The eastern branches drain the western slope of a portion of the Rocky Mountains proper, while the western branches head in a confused medley of nameless ranges, lying to the east of Tacla Lake and its feeders. The mountains have a fairly uniform height of about 4000 feet above the bottoms of the main valleys. Glaciers occur at the head of the Qua-da-cha River in the Rocky Mountains, and also on the Peak Mountains west of the Fishing Lakes. The rivers, as a rule, are swift and interrupted by frequent

rapids, but gently flowing lake-like expansions of considerable length occur on both the Finlay and the Omenica. Coniferous forests, unvarying in their monotony, extend over hill and valley throughout the district, up to a height of about 5200 feet above the sea. The principal varieties observed were the white and black spruces *(Picea alba and Picea nigra)*, the balsam fir *(abies subalpina)*, the black pine *(Pinus Murrayana)*, and the larch *(Larix Americana)*. Broad-leaved trees are represented by the aspen *(Populus tremuloides)*, the balsam poplar *(Populus balsamifera)*, the birch *(Betula papyrifera)*, and varieties of willow and alder. Forests.

Description of Routes.

Omenica River.

The Omenica River was brought into prominence by the discovery of gold on Silver Creek, one of its branches, by Ezra Evans, "Twelve-foot Davis" and a party of prospectors in 1868. On the announcement of the discovery of gold, miners flocked into the country by hundreds, and for some time the population of the district was estimated at from 1200 to 1500. It reached its maximum about 1879, and has since, as the creeks became exhausted, gradually declined. At the present time there are scarcely twenty whites in the whole country. Omenica River.

Very few accounts by actual explorers have been published on the Omenica country. Captain (now Sir W. F.) Butler ascended the lower part of the river in 1873, and describes it in his book entitled the *Wild North Land* (p. 274-309), and Mr. Horetzky explored the part between Hogem and Germansen Creek in 1879 (Report Canadian Pacific Railway, 1880, p. 82-83). In 1891 a party sent out by the British Columbia Government attempted to ascend the river, but turned back near the mouth of the Oslinca. Previous exploration.

The Omenica joins the Finlay from the west, about fifteen miles above the junction of the latter with the Parsnip, and is by far its largest tributary. From its mouth to the Black Cañon, a distance of five miles, its course is about 30° south of west. The stream is shallow in this reach and its current is extremely swift, the slope of the bed exceeding ten feet to the mile. Numerous gravel bars and islands, covered in places by huge drift-piles, obstruct the course of the stream, and divide it in places into several channels. Character of river.

At the Black Cañon, the Omenica cuts through a ridge of gneiss. The Cañon is about half a mile in length and varies in width from Black Cañon.

one to two hundred feet. Its walls are usually nearly vertical and in places exceed 150 feet in height. In low water, the navigation of the Cañon is reported to be easy, but in seasons of flood the swoollen stream is partly dammed back, and its effort to force a way through the narrow channel is attended with the production of such whirlpools and billows that its passage with large boats is exceedingly difficult and with small boats is impossible. The Omenica was still high when we reached the Cañon, and after an examination it was decided to make a portage. A trail was cut along the north bank, and the portage was made in less than a day. The ridge through which the Omenica cuts at the Cañon increases rapidly in height to the north, and develops into a mountain range the peaks of which exceed 5000 feet in height. Southward the ridge soon dies away.

Omenica above the Black Cañon.

Above the Black Cañon the valley is closed in for a mile or more by steep cliffs of sandstones, clays and conglomerates between which the stream rushes with torrential speed. Further up the stream bends to the north-west and follows parallel to the direction of the mountain ranges of the district, the rocky walls disappear, and the river, freed from confinement, enlarges to twice its former width. Above the bend the river follows a wide valley between the mountains as far the mouth of Tchutetzeca, a distance of ten miles. The Omenica in this reach is wide and swift; no rapids were met with, but short and strong "riffles," exceedingly difficult to ascend, occur every few hundred yards. A notable feature of the river here is the great drift-piles of logs which have been heaped up by the rapid current at all the bends, and on the heads of the numerous gravel-bars and islands around which the stream divides. The Tchutetzeca, a rapid stream about 150 feet wide, comes in from the north-west down the same valley occupied by the Omenica above the Cañon. It has not yet been explored.

Rapid character of Omenica.

Above the mouth of the Tchutetzeca the Omenica leaves the longitudinal valley followed below, and bends to the west. The declivity and current increase, and for some miles the river is simply a wild torrent plunging in a succession of rapids from bar to bar. The ascent of this portion of the river proved a matter of no ordinary difficulty. The tracking-line could not be used owing to the beaches being covered by high water, and the strength of the current rendered poling in many places equally impracticable. At the worst places wading in the ice cold water and pulling the canoes up foot by foot against the foaming stream, at the risk of stumbling on hidden and slippery boulders paving the channel, proved the only practicable means of ascent. Our progress here was very slow, and for some days

we scarcely averaged five miles per day. Five miles above the mouth of the Tchutetzeca, the Oslinca the largest tributary of the Omenica, comes in from the north. This stream is nearly equal in size to the main branch. It drains a large area of mountainous country lying between the Omenica and the south branch of the Finlay, all of which is practically unknown.

Above the mouth of the Oslinca, the Omenica cuts through a gneissic band, and for some miles lofty ranges of mountains press close down to the banks of the river. Six miles above the Oslinca, a contraction in the valley occurs, which is known as the Little Cañon. At this point the river makes a sharp double bend and strikes with its whole force against two points of gneissic rock which jut out in succession from either bank. The Little Cañon is comparatively easy to ascend, as the tracking-line can be used all the way by crossing the stream between the two rocks, but is dangerous to run at high water. It was at this point that Pete Toy, the Cornish miner (see Wild North Land, p. 291), who so efficiently assisted Capt. Butler at the Black Cañon, afterwards lost his life. Little Cañon.

Above the Little Cañon the current of the river sensibly diminishes. Riffles are still numerous, but they occur at longer intervals, and with few exceptions are of inconsiderable fall. Nine miles above the Little Cañon quiet water was reached, and we were able for the first time to proceed with paddles. Current diminishes.

From the mouth of the Omenica to the head of the swift portion of the river, is a distance of about thirty-five miles. The difference in elevation of the two points is approximately 425 feet, giving the river an inclination in this reach of about twelve feet to the mile, an exceptionably high grade for a stream of this size. Grade of Omenica.

From the head of the rapid water to Germansen Landing at the mouth of Germansen Creek, a distance of twelve miles, with the exception of a few small riffles the current is easy, from two to three miles an hour. The river has a width of about 100 yards, and for part of the way becomes very tortuous, winding from side to side of the wide flats which now border it. Before reaching Germansen Creek the Omenica turns almost due west and continues in this direction for many miles.

Germansen Landing, in the old days was a place of considerable importance, as most of the supplies for the Germansen and Manson Creek camps were brought from Tacla Lake across to the Omenica, floated down the stream in boats and landed here for distribution. In recent Germansen Landing.

years this route has been abandoned, and such supplies as are needed for the few remaining miners are brought in by pack-train.

Trail to Manson Creek.

A trip was made on foot from the Landing to Manson Creek. The trail, once trodden deep by gold-seekers, is now scarcely distinguishable in places, and in others is badly blocked by fallen timber. It leads across a burnt plateau for a couple of miles, and then descends into the deep valley of Germansen Creek. Extensive mining operations were once carried on at this point, but have long since ceased. A few deserted houses and some decaying flumes remain to tell the story of a brief activity and a sudden death. A mile farther up, the trail crosses Germansen Creek, at a place where the stream is closely confined between two rocky walls, by a dilapidated-looking bridge consisting of a single half rotten stringer bent downward under the weight of a number of dependant fragments. From the bridge we followed a rough trail along the east side of the stream to a mining camp which still preserves some signs of life. Three white men and one Chinaman were found here. Gold on Germansen Creek has been obtained both from river-flats and bars, and from gravels underlying the boulder-clay and referred to the early part of the glacial period. The flats have been worked out, but extensive areas of the auriferous glacial gravels are still untouched. Some work was being done on the latter at the time of our visit, but on too limited a scale to afford satisfactory results. Above the mining camp, the trail leaves Germansen Creek, crosses a ridge about 1300 feet high and then descends into the valley of Slate Creek, a tributary of Manson Creek. Two miles farther on we reached the town of Manson, situated on Manson Creek, formerly the richest creek in the district.

Gold on Germansen Creek.

Gold on Manson Creek.

Gold was first found on Manson Creek in 1891, and for two or three years the bars proved exceedingly productive, but since then the yield has been gradually diminishing, and at the present time the little work that is being done barely pays expenses. Gold was found in paying quantity along the bed of the creek for a couple of miles, and also in two of the tributary valleys. The glacial gravels here, as in Germansen Creek, are auriferous and have been worked to some extent, and it is highly probable that a large proportion of the gold found in the bed of the stream is concentrated from these deposits.

Trails.

Manson Creek is connected by trail with Quesnel by way of Stuart Lake, and with Hazelton on the Skeena by way of Tom's Creek and Tacla Lake, but the former trail, and the latter for part of the way, are in a bad state of repair, and mining operations are greatly hampered by the high freight charges on supplies. The rate from Hazelton, the cheapest route, amounts at present to 17 cents per pound.

We returned from Manson Creek by the same route and continued up the Omenica.

Above the mouth of Germansen Creek the Omenica occupies a wide valley, bottomed in places by marshy flats, behind which appear ranges of high mountains. The current for a considerable distance, except for a couple of short riffles, is easy, and in places the stream has a lake-like appearance. The change in the character of the river from the high grades and rocky bottoms which prevail in the lower reaches, to the slight inclination and basin-like alluvium-filled depression which it occupies here, point to crustal movements of some magnitude for their explanation. Character of river changes.

Slack current on the Omenica continues nearly to New Hogem, a distance, measured along the valley, of about twenty-three miles. The length of the river is fully one-third more, as in places it becomes very tortuous. Above New Hogem the Omenica enters a granite area and a rapid current is again encountered, which continued to Old Hogem, a distance of eight miles.

The character of the country through which the Omenica flows, with the exception of a few miles at its mouth, is everywhere mountainous. A range culminating in peaks exceeding 5000 feet in height, crosses the river a few miles above the cañon and extends far to the northward. West of this range the elevations are lower and have a more irregular distribution, but long before reaching Tacla Lake high rocky peaks again dominate the landscape. Mountains

From the eastern edge of the Rocky Mountains west to Tacla Lake (the western limit of the exploration), with the exception of the longitudinal valleys of the Finlay River and Tacla Lake, no flat lands of any importance are met with. The whole region is ridged up into a succession of lofty ranges. The valleys and the lower slopes of the mountains are, as a rule, densely timbered with the monotonous evergreen forest so prevalent in the north. The principal varieties are the white spruce *(Picea alba)* and the black pine *(Pinus Murrayana)*. The latter is usually found on dry sandy and gravelly flats and ridges. The smooth- and rough-barked poplars *(Populus tremuloides* and *P. balsamifera)* occur in some abundance locally, but are usually confined to the valley. The summits of all the higher mountains are bare, as the forest seldom ascends in this region beyond an elevation of 5200 feet. Absence of plains. Forest.

Above Old Hogem the Omenica bends more to the north and runs nearly parallel to the strike of the rocks. As little geological information was obtainable by following the river, it was decided to leave Trail to Tacla Lake.

it and to make a traverse on foot to Tacla Lake across the strike of the rocks. The old trail from Hogem to Vital Creek is still in good condition. From Vital Creek to Tom's Creek the trail is little used, but for the remainder of the distance on to Tacla Lake a good trail has been recently built by the Provincial Government in order to facilitate communication with the mining camp at Tom's Creek. The trail leaves the Omenica at Old Hogem and follows up the valley of Silver Creek to Vital Creek, a tributary of the latter, passing over sandy and gravelly flats, forested with black pine, most of the way. Before reaching Vital Creek the trail leaves the wide valley of the Omenica and enters the mountains. Vital Creek is a rapid mountain stream twenty or thirty feet wide and four or five miles long. Gold was discovered on it in 1869, and it has been worked more or less ever since, but latterly with but little profit.

Vital Creek.

Gold on Vital Creek.

Three white men, including Mr. Vital the discoverer, and some Chinamen, were engaged on it at the time of our visit, but they did not speak hopefully of their prospects, and the stream may be regarded as worked out. A considerable quantity of silver amalgam (arquerite) has been found with the gold in the alluvial washings on Vital Creek. It has not been found *in situ*.

From Vital Creek the trail follows up Silver Creek for a couple of miles, and then turns westward up a branch running parallel to Vital Creek. Three miles from Silver Creek the valley widens out, and for some miles its bottom is filled with a succession of small lakes connected by short winding streams. Nine miles from Silver Creek we reached Tom's Creek, a small mountain stream coming from the south. Tom's Creek, as an auriferous stream, was not discovered until 1889, and was practically worked out during the years 1890–91–92. In 1892, about a dozen white men and Indians and a few Chinamen were at work on it, but few of the claims did much more than pay expenses. The discovery of an auriferous stream like Tom's Creek, close to Vital Creek, twenty years after the finding of gold on the latter, shows what a small proportion of the country has yet been thoroughly prospected.

Tom's Creek.

From Tom's Creek we followed up the wide valley of Kenny Creek for nine miles, passing several small lakes on the way, to the summit of the pass between the Omenica and Tacla Lake. The elevation of the summit is approximately 1644 feet above Tacla Lake, or 3915 feet above the sea. After crossing the summit, the track followed for a short distance a stream flowing towards Tacla Lake; then, after crossing a spur from the mountains, it descends rapidly towards Tacla

Lake, reaching the latter about half a mile below the old landing. Three miles from the landing a sharp descent of 700 feet was made over the face of an escarpment running parallel with the lake.

Tacla Lake is one of those long narrow bodies of water so prevalent throughout British Columbia. It occupies a great longitudinal valley, running parallel with that at the western base of the Rocky Mountains which now holds the Finlay and Parsnip. The two valleys are separated by about eighty miles of rough mountainous country. Tacla Lake.

Tacla Lake was not examined except for three or four miles south of the landing. It is from two to three miles in width, and is bordered on both sides by heavily timbered flats several miles wide. It is separated from Babine Lake, which occupies a somewhat similar valley farther to the west, by the Fire-pan Mountains.

The most notable feature of the country in the latitude of the Omenica and Finlay rivers, or from latitude 55° 30′ to latitude 57° or beyond, is its universal mountainous character. In this latitude, the whole country from the eastern edge of the Rocky Mountains westward to the Pacific Ocean is destitute of plains of any considerable extent, and with the exception of the breaks where the region is crossed by the valleys mentioned above, is covered with a succession of mountains and mountain ranges varying in height from 3000 to 5000 feet above the valleys. In no other part of British Columbia is the country so persistently mountainous across the whole Cordilleran belt. Mountainous country.

Finlay River.

The Finlay River is named after John Finlay, who ascended it in 1824 in the interests of the North-west Company. The journal kept by Mr. Finlay on this journey has never been published. It is now at Cumberland House in the possession of Mr. James McDougall of the Hudson Bay Co., where it was seen and some extracts taken from it by Mr. J. B. Tyrrell in 1894. Miners are also reported to have ascended the river to varying distances during the Omenica excitement, and in 1891 an exploring expedition sent by the British Columbia Government ascended it to Fort Grahame a distance of about forty-five miles. Finlay River. Previous exploration.

The Finlay River is much the larger of the two streams which form Peace River, and is practically the upper part of that river. It has a General character of Finlay River.

total length of about 310 miles,* and ranges in width from thirty yards, where it issues from the expansion at the Fishing Lakes, to 300 yards near its mouth. The Finlay drains a region which is everywhere of a mountainous character and is itself bordered throughout the whole of its course by lofty mountain ranges. Its navigation, for two hundred miles above its mouth, with the exception of one cañon half a mile in length, is easy, the current seldom exceeding five miles an hour, but farther up, its course is interrupted for many miles by a long succession of cañons and rapids. Its branches interlock with tributaries of the Skeena, Stikine and Liard rivers, and low passes through the mountains from one basin to the other are not uncommon.

Current and width.

The Finlay River from its mouth to its junction with the Omenica, winds through a wide flat, skirting the western base of the Rocky Mountains. It has a width in places of 300 yards or more, but is usually divided into several channels by islands and gravel bars. The current is easy, averaging about three miles an hour at a medium stage of water. The bars along this stretch of the river are all auriferous, and one of them, called Pete Toy's Bar after the discoverer, yielded a large amount of gold in the early days of mining in the country. The gold in this reach is probably mostly derived from the Omenica.

Auriferous bar.

The Omenica River contributes about one-fifth of the whole water of the Finlay, at its confluence. A mile above the Omenica, the Ospica joins the Finlay from the east. It enters the latter in two branches each about a hundred feet wide. The Ospica was ascended and prospected by a party of miners some years ago, but no paying bars were discovered. It runs in a southerly direction, and cuts off a long rounded ridge from the main range of the Rockies. Above the Ospica, the Finlay runs, with the exception of one bend, in a nearly straight direction for twelve miles. It has a width here of about 200 yards and a current of scarcely two miles an hour, the slowest in the whole course of the river. It occupies a depression about four miles in width, bounded on the west by a gneissic ridge which commences at the Black Cañon on the Omenica and runs northward with gradually increasing height, and on the east by the rounded ridge which

Ospica River.

*The total length of the Finlay-Peace-Mackenzie watercourse is approximately 2362 miles, made up as follows:—

	Miles.
Finlay River	310
Peace "	757
Slave "	240
Great Slave Lake	90
Mackenzie River	965
	2362

separates the Ospica from the Finlay. The latter is overlooked, farther to the east, by the peaks and ridges of the main range of the Rocky Mountains. Finlay Valley.

The depression in which the Finlay flows, is floored with a varying thickness of sands, clays and gravels, forming a forested plain, in which the river has cut a valley to a depth of about a hundred feet. No rock is exposed along this part of the river. The material shown in the banks of the valley contains numerous scratched and polished pebbles and boulders, and is evidently of glacial origin, but appears in some instances to have been redistributed. Above the straight reach just described, on to Fort Grahame, a distance of about twenty-one miles in a straight line, the Finlay becomes more tortuous and is obstructed by islands and bars, the river being frequently divided into half a dozen different channels. Absence of rock exposures.

Drift-piles are everywhere present. They occur at the heads of all the bars and islands, and, alternating from one bank to the other, form in places an almost continuous line along the river. The drift-wood is derived from the washing away of the forested flats bordering the river, and the enormous amount carried down during high water each year measures the destructive power of the stream. Rapid changes in the course of the river are notable features in this reach, the main channel of one season being often represented in the next by a scarcely used slough. Drift-piles.

Near Fort Grahame, the mountains on the west, approach close to the river and sections of limestone and gneiss are exposed. An ascent of the range east of the fort was made on August 10th. The river is bordered on the east by a series of scarps and terraces rising up to a height of 275 feet with a width of about three miles. The main terrace has a height of 175 feet above the river and is thickly wooded with black pinc. Near the mountains the pine is replaced by white spruce. The lower slopes of the mountain are well forested up to a height of 2000 feet above the river, but above that elevation the trees gradually thin out, and a thousand feet higher up they cease altogether. The elevation of the timber-line in this district is approximately 5200 feet above the sea. From the point ascended, the valley of the Finlay could be followed southward to the mouth of the Omenica and northward could be seen stretching out in a nearly straight direction for over sixty miles, or as far as the eye could pierce the haze. In all this distance it preserves a nearly uniform width of from four to six miles. Looking up the valley, the most striking object in view was a range of mountains about forty miles distant, Ascent of mountain at Ft. Grahame. Elevation of timber-line.

which appeared in the evening light to be almost pure white. They were afterwards examined and found to be composed of a much altered compact limestone. Westward, range after range of nameless mountains, running nearly parallel to the valley of the Finlay, extended to the horizon, while eastward the view was soon obstructed by the higher peaks of the central ranges of the Rockies. Patches of snow cling round the summits of most of the higher mountains, but no flowing glaciers were seen. The heights of the principal peaks range from 7000 to 7500 feet above the sea.

Trails.

The range bordering the valley on the west is broken through opposite Fort Grahame by a small stream flowing into the Finlay, up which a trail leads which can be followed through the mountains to Bear Lake, a distance of sixty or seventy miles. A second trail from Fort Grahame is stated to run eastward to the Liard.

From Fort Grahame to the Ingenica, a distance of sixteen miles in a straight line, and about twenty miles following the curves of the river, the Finlay is characterized by the same features which prevail below. It is divided into numerous channels by islands and bars, and holds a nearly straight course along the centre of the great depression it occupies, never touching the mountains on either side and seldom even cutting into the bordering terraces. The current is rapid, averaging fully five miles an hour.

Ingenica River.

The Ingenica is the first large stream which enters the Finlay from the west above the Omenica. It is a clear, rapid river fifty to sixty yards wide, and is reported to be navigable up to the forks, a distance of about thirty miles, above which it is filled with rapids.

An Indian trail to Bear Lake runs along its bank. The Ingenica is well worthy of being prospected, as it must cut through the same band of green and dark schists from which the gold in the Omenica country is derived. Fine gold was found in the wash at the mouth of the river.

Fourteen miles above the Ingenica, the Finlay is narrowed in by a cañon named Deserters' Cañon by Finlay. For part of the distance the stream presents its usual characteristics, but five miles below the cañon the islands and bars disappear and it is confined to one channel varying in width from to 200 to 250 yards. Above the Ingenica the Finlay bends slightly to the west, and at the cañon it approaches the base of the range bordering the valley on the east. On the west the space between the river and the mountains is occupied by a plain five to six miles in width wooded with poplar, spruce, and black pine.

Deserters' Cañon is situated about ninety miles above the mouth of the Finlay River, and is the first interruption to its navigation. This cañon is about half a mile long and in the narrowest places scarcely exceeds a hundred feet in width. It is cut through hard conglomerate and sandstone. The walls, except at the lower end, where there is a steep conglomerate cliff, are not very high. The channel is crooked and is interrupted by several bad riffles. Deserters' Cañon can be run at certain stages of water but its navigation is dangerous. A good portage-track half a mile in length has been cut out by the Indians along the west bank. Deserters' Cañon.

Above Deserters' Cañon, the Finlay makes a couple of great bends to the west, above which it receives the A-ki-é River from the east. At the bends high cut-banks of boulder-clay, silts and gravel, are exposed. The white limestone mountains seen from Fort Grahame are now directly west. This range commences west of the Cañon and extends north-westward. It evidently, from its condition, marks a line of disturbance and probably of faulting. The range immediately east of the valley is still composed of gneiss and mica-schists, but farther back, bare sharp crested mountains come into view, which are probably built of limestone. White mountains.

The Akie River has not been explored. It enters the Finlay in two branches, the larger of which is one hundred feet wide; its valley is wide and cuts straight back into the mountains for a distance of about twelve miles; it then bends to the north, but sends a branch southward. The wash in the bed of the Akie is principally limestone and does not contain gold. Above the mouth of the Akie, the Finlay pursues a very tortuous course as far as Paul's Branch, a distance measured in a straight line of about twenty-one miles, but following the course of the river for thirty-five miles. In several points of this reach, the river is bordered by high gravel and boulder-clay banks, in some cases exceeding 250 feet in height. The valley maintains a width of from five to six miles for part of the distance, but six miles below Paul's Branch, a range rises up west of the river which narrows it in to about three miles. The ranges bordering the valley on both sides have a height in this latitude of about 3000 feet above the valley. Akie River.

Paul's Branch is a small stream about thirty feet in width. Its valley is narrow and cañon-like where it breaks through the gneissic range that borders the Rockies on the west, but widens out when it reaches the softer rocks behind. No gold was found on Paul's Branch, but good prospects were obtained from a couple of streams which enter Paul's Branch.

2

Lower mountains.

the Finlay from the west, a few miles lower down. The mountains east of the bordering gneissic range of the Rockies are comparatively low in this latitude, and are separated by wide wooded valleys often holding lakes of considerable size. Their lower elevation is due to the relatively softer and more easily eroded nature of the argillites and calc-schists of which they are composed. Farther back, near the centre of the range, the calc-schists are replaced by hard limestones, and higher and bolder-looking mountains again prevail.

From Paul's Branch to the Qua-da-cha, or Whitewater, a distance of eleven miles, the Finlay runs in a nearly straight direction, skirting the base of the range bordering it on the east. The width of the river here is about 250 yards, and its current has a rate of about four miles and a half an hour.

Quadacha River.

The Quadacha, or Whitewater, as it is appropriately termed on most of the maps, is the largest stream which enters the Finlay from the east, and is usually referred to as "The Fork," although its volume is scarcely one-sixth that of the main river. It is a deep rapid stream about one hundred feet wide. Its water is filled and whitened with fine sediment, evidently derived from glaciers, and presents a strong contrast in this respect to the clear blue water of the main stream. The two streams flow side by side for several miles before commingling. The Quadacha follows the western side of the same valley which the Finlay has occupied for so long, for several miles, and then turns eastward into the Rockies. It is reported by the Indians to fork soon after entering the mountains, one branch coming from a large lake, while the other heads in a glacier near the centre of the range. At the Quadacha, the Finlay bends to the west, and three miles further on receives the Tochieca, a stream about seventy-five feet wide. Soon after, still turning westward, it leaves the great valley which it has hitherto occupied. The valley extends northward with undiminished size, although it now holds only an insignificant tributary of the Finlay.

Great valley.

The great Inter-montane valley referred to above, and of which mention is so frequently made in this report, forms one of the most important topographical features of British Columbia. It crosses the international boundary about longitude 115° 10′ W. and runs in a direction N. 33° W. along the western base of the Rocky Mountains, separating the latter from the Selkirks and other ranges on the west, for a distance of over 800 miles. It is entirely independent of the present drainage systems of the country, as it is occupied successively, beginning at the boundary, by a number of rivers belonging to distinct

systems, among which are the Kootanie, the Columbia, Canoe River, the Fraser, Bad River, the Parsnip, the Finlay and the Tochieca. The link between Bad River and the Fraser has not yet been surveyed, and its extension, if any, beyond the Tochieca is still unknown. Its width varies from two to fifteen miles, and it is everywhere inclosed, except for some distance along the west bank of the Parsnip, by mountain ranges varying in height from 3000 to 6000 feet or more above the valley.

Width of valley.

The width of the valley does not depend on the size of the stream which occupies it at any particular place. It is fully as wide along the smaller streams and at the watersheds which separate the different streams, as along great rivers like the Columbia and the Finlay. The average height of the bottom of the valley above the sea is about 2300 feet, and the variation in height is about 1000 feet. The heights of the watersheds in the valley are approximately as follows: Kootanie-Columbia, 2740 feet; Columbia-Fraser, 2900 feet; Peace-Liard, 3100 feet. The increase in height of the watersheds toward the north, does not hold good in regard to the depressions. The Columbia leaves the valley at a height of 2050 feet, the Fraser at a height of 2100 feet (?), and the Peace at a height of 2020. The two former streams break through the ranges bounding the valley on the west, while the latter cuts through its eastern walls. None of the streams occupying the great valley, the salient features of which have just been described, are doing much rock-cutting at the present time. Secondary valleys are being sunk in most places through the old floor, but the cutting is usually through glacial deposits. The principal exception to this is in the case of the Columbia, which has done considerable rock excavation in the reach extending from above Donald down to the Big Bend, the point at which it leaves the valley. It now flows, for part of the distance, in a rock-walled narrow channel eroded through the floor of the old depression. In no place is any widening of the old valley going on.

Height above the sea.

Age of valley

The age of the valley has not been worked out, but it is evident that it long antedates the inception of the present drainage system of the country, and may have been in existence before the elevation of the Rocky Mountains proper. Rocks of Tertiary age (probably Miocene) are supposed by Dr. Dawson to underlie part of the southern portion of the valley, while sandstones and conglomerates of Laramie age are found in places along both the Parsnip and Finlay. Glacial deposits are present throughout its whole extent.*

*See on this great valley, sketch of Phys. Geol. and Geol. of Canada, Selwyn and Dawson, 1884, p. 34. Annual Report, Geol. Surv. Can., vol. I. (N.S.), p. 28 B.

The Finlay River, as already stated, turns to the west above its junction with the Tochieca and breaks a gap about a mile wide through the range bounding the valley on that side. The part of the range

Prairie Mountain.

adjoining the river on the north, is called Prairie Mountain by the Indians, on account of the bare slope it presents on the southern exposure. An ascent of Prairie Mountain was made. It is a steep-sided flat-topped elevation about 2400 feet high. The aspen and spruce forest which covers the narrow plain at its base extends up its lower slopes for a few hundred feet, above which the trees become more scattered and inclose large grassy areas. The summit of the mountain is covered with low shrubs, varied at intervals with clumps of stunted spruce *(Picea alba)*, balsam *(Abies subalpina)* and black pine. Farther to the north the ridge increases in elevation and is surmounted by bare rocky peaks.

View from Prairie Mountain.

From the point ascended, a view of the great valley which holds the Finlay and the Tochieca was obtainable for fifty miles or more in each direction. Northward, as far as visible, it maintains a straight wide course, and is characterized by the same features which prevail below. The range bordering it on the east is regular and well defined, and has an elevation of about 2500 feet above the level of the valley. This is succeeded by somewhat lower round-topped ranges, behind which is a series of massive looking limestone mountains forming the summit of the range. The latter support the large glacier from which the Quadacha issues. Westward, mountains appeared everywhere, apparently increasing in elevation towards the west, and culminating at a distance of forty or fifty miles in a range, the higher peaks of which approach 6000 feet in height. A number of small glaciers appear dotted along this range at the bases of the higher peaks. No plains were visible in any direction.

The Finlay River, after passing Prairie Mountain, bends again to the north-west, and runs for some miles nearly parallel to the continuation

Rapids.

of the great valley occupied by it below. The current gradually increases and twelve miles above the mouth of the Tochieca its navigation, except at very low water, is practically stopped by a long cañon. We ascended the cañon for two miles, and then as an examination showed that the river for many miles ahead was simply a succession of cañons, riffles and rapids, it was decided to câche the canoes and continue the exploration on foot.

Long Cañon.

The Long Cañon has a length of about five miles. The river in this distance is frequently narrowed in to less than a hundred feet in width, the constriction often resulting in the production of wild rapids. The walls are irregular and are built partly of Tertiary conglomerates, and

R. G. McConnell, Photo., Aug., 1893.

MOUTH OF LONG CAÑON, FINLAY RIVER.

partly of Palæozoic calc-schists and limestones, arranged in steep and often vertical cliffs from fifty to one hundred feet in height, and capped above by steeply sloping scarped glacial beds. The total depth of the gorge at the upper end exceeds 600 feet. Above the Long Cañon, the Finlay for five miles is a swift shallow stream about 150 yards wide. It is then interrupted by a second but shorter cañon, through which its waters pour in an exceedingly turbulent manner. The river for some miles above the second cañon was not examined.

Leaving the river at the lower end of the Long Cañon, we climbed out of the valley, here about 300 feet deep, and skirted for some miles the base of the range bounding the valley on the west; then, turning more to the north, we descended into the valley of a small stream, which falls into the Finlay below the second cañon. This stream occupies the eastern slope of a wide valley which runs directly westward and meets the Finlay again beyond the great semicircular bend which the latter describes above the second cañon. The space between this valley and the Finlay is occupied by a long mountain, about 3000 feet high above the valley, which was named Mt. Finlay. Leave the river.

Travelling up the valley proved to be very difficult owing to fallen timber, and we were obliged, for most of the way, to follow the bed of the stream, crossing and recrossing it continually. Nine miles from our câche, the stream that we were following turned south into the mountains. Here we left it, and, continuing westward, shortly afterwards reached a couple of narrow lakes, the first about two miles and the second about one mile in length. No water was flowing from these lakes, but in seasons of flood they evidently drain eastward, as the valley ascends beyond them. Difficult travelling

Half a mile from the second lake we reached the summit of the pass, and three miles further on came again to the Finlay, here flowing in a north-easterly direction. The river at this point is about 150 yards wide and is swift and shallow. We followed up the right (east) bank, and two miles further on reached the junction of the Finlay and Thudaca, a rapid mountain stream heading in the Peak Range. Above the Thudaca the Finlay has a rapid flow, and is interrupted by several small falls and rapids for a distance of six miles. Above this reach, what appears to be an old lake basin begins, the rocky banks and bed which characterize it below, suddenly disappear, and are replaced by clay, silt and gravel. The current diminishes to about a mile and a half an hour, and the stream expands to twice its usual size. The flat bordering the river is intersected by sloughs, and holds a couple of small sheets of water, known to the Indians as the Fishing Lakes. Reach the Finlay. Diminution in current.

The valley here has a width of about a mile and a half, and is bordered by mountains, 4000 to 5000 feet above the river, belonging to the Peak Range. Numerous small isolated glaciers, descending to a height of about 2500 feet above the river, occur in the depressions between the summits, but no extended ice-field was noticed. The expanded lake-like portion of the Finlay has a length of about eighteen miles. Near its head, the river divides into several branches, none of which were explored by us. The western branch (called Thucatade by Finlay) was ascended by Mr. Finlay, and is stated by him, in the journal referred to before, to be thirty-five miles in length and to head in a narrow lake, sixteen to twenty miles long, called Lake Thutade by the Indians.

Glaciers.

Geological Observations.

Omenica River Section.

Rock exposures.

Rock exposures on the Omenica commence at the Black Cañon, five miles above its mouth. Below the Black Cañon the valley is cut through the glacial and alluvial deposits which floor the narrow plain bordering the Finlay. A good section of the latter, consisting here of clays, sands and gravels, was observed about a mile above the mouth of the river. A landslip of considerable magnitude occurred at this point not long ago, by which material from the north bank of the valley was carried right across the main channel of the river and deposited on the further side. No permanent change in the course of the stream was effected by this slide, as the blocked channel was quickly cleared by the rapid river.

Landslip.

Rocks at Black Cañon.

At the Black Cañon, the valley for half a mile is bordered by sharp rocky walls consisting of medium-grained muscovite gneisses, micaceous and chloritic schists, and quartzites. At the upper end of the cañon the gneisses and schists are overlaid by a bed of hard grayish limestone, filled with mica, quartz, and other impurities. The general strike of the rocks at the cañon is S. 58° E. and the dip is south-westerly at an angle of 28°. The gneiss and mica-schists of the Black Cañon represent the oldest rock series found in the Omenica district and are undoubtedly of Archæan age. They run in a north-westerly direction parallel to the course of the Finlay for many miles. Their extension southward has not been worked out.

Laramie rocks.

The Archæan gneisses and schists of the Black Cañon, are succeeded in the valley of the Omenica by a series of shales, sandstones and conglomerates of Laramie age. These rocks occur in several places in

the Omenica and Finlay River districts, but so far as observed are everywhere confined to the valleys. They usually strike parallel, or nearly so, to the general direction of the valleys in which they lie, and conform approximately in dip to the older rocks on which they rest. Above the Black Cañon the strike is S. 28° E. and the dip is south-westerly at an angle of 30°.

The materials of these conglomerates and associated beds have been derived from the Archæan gneisses and schists and the Palæozoic schists and limestones which floor the surrounding country. The conglomerate consists of pebbles of quartz, felsite, chert, schist and limestone, imbedded in a soft sand or clay matrix, occasionally hardened by a feruginous cement. The shales are usually dark in colour, are coarsely laminated and often pass by the gradual addition of arenaceous material into a shaly sandstone. Mica enters largely into the composition of the rocks of this series, and in some instances beds a foot or more in thickness were observed, which consisted almost entirely of this material.

Fossil leaves and other vegetable remains are abundant in some of the shales and shaly sandstones, but are usually in a somewhat fragmentary condition. Among the specimens brought back, Sir J. Wm. Dawson has recognized fragments of the stem of an *Arundo*, *Sequoia Langsdorffii* and *S. Couttsiæ*, a *Populus* like *P. Arctica*, a *Platanus*, a *Quercus*, a *Viburnum*, probably *V. asper*, Newberry, and a carpolite resembling *Leguminosites arachnoides*, Lesquereux. The only animal fossils found were a couple of *Ostracods* which have not yet been specifically determined. Fossils.

The Tertiary beds are exposed above the cañon in a nearly continuous section for about a mile, and at intervals for several miles farther. Two miles and a half below the mouth of the Tchutetzeca a ledge of limestone projects out from the left bank, and is also exposed on an island in the centre of the stream. The limestone here is very hard, and evidences its proximity to a line of strong disturbance in its whitened and cracked appearance, and in the schistose condition of some associated shaly beds. A mile further up, an exposure of hardened shales, holding some beds of impure limestone, was noticed in the right bank, which probably belongs to the Laramie series. At the bend of the Omenica above the mouth of the Tchutetzeca, grayish-limestones are exposed in several places, and they also occur in the mountains north of the river. No fossils were found in these limestones, and their age is therefore uncertain, but they probably belong Limestone exposures. Age of limestone.

to the Castle Mountain group, a series which includes beds ranging from the Middle Cambrian to the Cambro-Silurian.*

Gneiss.

Above the limestone outcrops just referred to, exposures are wanting for a distance of over two miles and then hard garnetiferous gneiss appears in the banks of the valley. The Bow River series of conglomerates, quartzites and argillites which usually separates the Castle Mountain limestone from the Archæan was not observed and may be cut off by a fault.

Archæan rocks.

Archæan rocks commence about a mile and a half below the mouth of the Oslinca and are exposed along the river for a distance of twelve miles. The principal variety consists of a medium grained biotite-gneiss. Muscovite- and hornblende-gneisses are also present, but are less abundant. A felspathic augen-gneiss occurs in one section and garnetiferous gneisses were observed at several horizons. Lustrous mica-schists and soft hydro-mica schists alternate with the gneisses in bands and beds, and constitute a considerable proportion of the formation. The Archæan outcrop crossed by the Omenica has the form of a great anticline, with its eastern limb dipping in a north-easterly direction at angles ranging from 30° to 70° and the western limb dipping in a south-westerly direction at correspondingly steep angles. The strike is S. 48° E.

Bow River series.

The Archæan gneisses and schists are overlain by the Bow River series consisting here, as elsewhere, of grayish conglomerates and quartzites, and hard dark slates. The conglomerates are rather fine-grained, the pebbles seldom exceeding a third of an inch in diameter, and are crushed and altered in places into a schistose condition. The pebbles consist principally of quartz and felspar. The Bow River rocks are exposed along the river for two miles. They are succeeded and overlain in turn by grayish unfossiliferous limestone similar in character to that exposed below the mouth of the Tchutetzeca, and, like it, probably belonging to the Castle Mountain group. It dips to the south-west at angles ranging from 40° to 50°.

Castle Mountain limestones.

Order of succession.

The three series of rocks briefly described above, viz., the Archæan gneisses and schists (Shuswap series), the Bow River conglomerates, quartzites and slates, and the Castle Mountain limestones, occur in a similar succession to that on the Omenica, so far as observed, all along the Rocky Mountain range. In the section previously examined on the Bow River the lower beds do not come to the surface, and in other places the relationship is obscured by faults and overturns, but when-

*For a definition of this and the Bow River series, see Annual Report, Geol. Surv. Can., vol. II. (N.S.), pp. 240, 29 D.

ever the section is normal and complete the above described order obtains.

The Bow River conglomerates have a thickness on the Omenica of from 4000 to 5000 feet. The thickness of the Castle Mountain limestone was not ascertained.

The limestones are succeeded by a series of rocks which are entirely different in character from those just described and are mainly of volcanic origin. At the bend of the river below Germansen Landing, three rounded hills, each about a thousand feet high, occur, which are built principally of a green diabasic rock described by Mr. Ferrier as a compact diabase tuff. This rock is massive in character along its eastern border, but proceeding westward, lines of stratification are gradually developed, and in a short distance it passes into a well-foliated green schist, interbedded in places with darker schists, apparently argillaceous in character. The lithological succession at this point, indicates a gradual passage from massive volcanic rocks through an imperfectly bedded pyroclastic variety to well foliated schists probably derived from volcanic ash. Green volcanic rocks.

At Germansen Landing, green schists, striking S. 48° E., and dipping at high angles, are exposed. In proceeding up Germansen Creek the rocks, while apparently all belonging to the same series, display great variety. The predominant type for some miles is a green ash rock pressed and altered into a schist. Interbedded with it are layers of grauwacke, felsite, and hällaflinta, and bands of dolomite, serpentine, and magnesite. At one point below Clinton's an exposure of serpentine, sprinkled with decomposed crystals of felspar, was observed. Near Clinton's, on Germansen Creek, the green schists are replaced largely by dark evenly bedded argillites. On the trail between Germansen Creek and Manson Creek, both green schists and dark argillites are largely developed. The latter are often speckled with yellow spots, due to decomposed pyrite crystals. The strike of the schists and argillites has an average direction of S. 55° E. The dips are variable, but are usually steep. Rocks on Germansen Creek.

Granite is reported to occur on Manson Creek, a mile above the town of Manson. Its presence in the neighbourhood is evidenced by the number of granite boulders of all sizes, which are scattered everywhere over the face of the country. Granite.

Between Germansen Landing and New Hogem, the rocks exposed along the Omenica consist of green and dark schists similar to those outcropping on Germansen Creek, alternating with indistinctly foliated diabase-tuffs. The latter in some places are destitute of stratification

and are not distinguishable in the field from the massive diabases. They vary greatly in texture, passing gradually from a compact crypto-crystalline condition to a rock of medium grain.

Granite.

At New Hogem the schists and diabase-tuffs are replaced by a dark-coloured medium-grained granite, usually of a hornblendic type. An agglomeratic-looking rock, made up of granite and diabase débris, probably a junction material, was found in the wash of a small stream which enters the Omenica immediately below New Hogem.

Granite outcrops along the Omenica from New to Old Hogem, a distance of about eight miles, and extends north and south of the river in a direction parallel, or nearly so, to the prevalent strike of the neighbouring schistose rocks. The southern limit of the area was not ascertained, and it is possible that it may be continuous with the granite outcrops on Manson Creek.

Green schists.

From New Hogem the trail to Tacla Lake via Vital and Tom's Creek was followed. An occurrence of granite half a mile south of the river marks the western boundary of the granite area, as a short distance away, greenish schists and dark gray argillites similar to those on Germansen Creek crop out in the valley of Silver Creek. Outcrops of the same argillites and schists occur in numerous exposures along the route traversed until within a few miles of Tacla Lake. They are instratified in places with grauwacke and beds of felsite. Hällaflinta and amphibolite are also not infrequent. The beds dip at high angles, usually towards the south-west, and are occasionally vertical. Seven miles from Tacla Lake, the argillites and associated rocks are replaced by conglomerates, sandstones and shales of a somewhat similar character to those on the Omenica above the Black Cañon. Conglomerates were also found on the shores of Tacla Lake, and they probably form the basement of the wide valley in which the lake is situated.

Conglomerates.

The Tacla valley conglomerates are more indurated than those on the Omenica and have been subjected to greater disturbances, the tilting of the beds often amounting to 70° and over. The age of the conglomerates is doubtful, as no fossils were obtained from them, but they probably belong to the Cretaceous.

Finlay River Section.

Finlay River section.

The Finlay section is much inferior to that afforded by the Omenica, as the direction of the river for long distances is parallel or nearly so to the strike of the rocks. No exposures occur along the lower part of the river. From its mouth up to the Omenica, the Finlay winds

through a low alluvial plain without touching the bordering highlands or mountains. Above the mouth of the Omenica the banks increase in height, and where cut into by the stream, show glacial sands, gravels and clays, holding numerous scratched and polished boulders.

A mile and a half below Fort Grahame, an exposure of hard grayish contorted limestone appears on the west bank of the river, underlying mica-schists and gneisses. The limestone strikes N. 40° W., and dips to the west at an angle of 70° or over.

An examination was made of the mountains bordering the valley in the vicinity of Fort Grahame. The valley here has a width of about five miles and is terraced on both sides of the river. The main terrace has a height above the stream of 175 feet. The other terraces, although plainly visible from a distance, could not be distinguished during the ascent. Water-worn pebbles were found up to a height of over 2000 feet above the river. Terraces.

The rocks observed consisted of lustrous mica-schists, mica-gneisses, and hornblende-schists, bedded diorites, quartzites, and occasional bands of whitish crystalline limestone, all belonging to the Shuswap series. Rocks in mountain east of Ft. Grahame.

At the base of the mountains the rocks dip to the south-west, at a high angle, but further up the dip diminishes and at the summit the beds are nearly horizontal. The strike is approximately N. 40 W., or parallel to the direction of the valley.

The mountain west of the valley was ascended by Mr. Russel and are reported by him to consist of mica-schists, gneisses and limestones, similar to those east of the valley, dipping at high angles.

No glacial striæ or grooves were noticed on either slope, but the rocks in places appeared to have been smoothed and rounded by ice moving in a south-easterly direction. From Fort Grahame to the mouth of the Ingenica, a distance of about twenty miles, no exposures were noticed along the valley. The bordering mountain ranges, judging by the material brought down by numerous tributary streams, are built mainly of gneiss and mica-schists. The latter outcrops in a couple of places a short distance above the mouth of the Ingenica. Absence of glacial striæ.

Six miles above the mouth of the Ingenica, plant-bearing conglomerates and sandstones of Laramie age appear in the valley. These beds are similar in character to those in the Omenica, previously described. They appear to be confined entirely to the great valleys of the district and to be absent from the highlands, and if ever deposited on the latter have been entirely swept away. They rest partly on an

Archæan, and partly on a Palæozoic floor, and have participated to some extent in the later folding which has affected the region.

The pebbles of the conglomerates seldom exceed half an inch in diameter and consist of rounded and sub-angular fragments derived from the disintegration of the schists, slates and quartzites of the neighbourhood. Below Deserters' Cañon, a ridge of hard conglomerate and sandstone, through which the stream has cut a narrow gorge, crosses the valley. At the lower end of the cañon the walls are vertical in places, but farther up, the banks have weathered into a steep slope.

Deserters' Cañon has the appearance of a recent channel, and probably owes its origin to an alteration in the course of the stream during the glacial period, as the easily eroded material of which its banks are formed could not have withstood the assaults of a large swift stream heavily charged with sediment, such as the Finlay, for any lengthened period.

Shuswap series.

The Tertiary conglomerates and associated rocks are replaced, a short distance east of the Deserters' Cañon, by the gneisses and mica-schists of the Shuswap series, but extend in a westerly direction for four or five miles, or as far as the base of the mountain range bounding the valley in this direction.

White limestone mountains.

Above Deserters' Cañon, the valley is bordered on the west by a conspicuous range of white mountains from 2000 to 3000 feet in height. On closer examination these proved to be composed of a fine-grained, whitish, compact limestone. This rock weathers in places to a light yellow or rusty colour, and occasionally is very siliceous. No fossils were found in it, but from its position relatively to the Shuswap series it was referred to the Cambrian. The limestone is very much disturbed and probably lies along a line of faulting running with the valley.

Bordering ranges.

The schists and gneisses of the Shuswap series form the bordering mountain ranges on both sides of the Finlay below the mouth of the Ingenica, but above that point, while still continuing on the east, they recede toward the west, and are replaced by the limestones referred to above.

Laramie conglomerates.

From Deserters' Cañon to Paul's Branch, a distance of thirty miles in a straight line, the Finlay winds through the centre of its valley without touching the bordering mountain ranges. The valley in this stretch is floored throughout with Laramie conglomerates, sandstones and shales, exposures of which occur at intervals all along. These rocks here are usually little indurated and occasionally hold small lignite seams. Fossil plants occur in many of the beds.

Ten miles below Paul's Branch, banks of glacial deposits 225 feet high occur at the bends of the stream. The banks are sloping below, but are capped with steep bluffs above consisting mostly of coarsely stratified gravels interbedded with bands of hard boulder-clay filled with scratched boulders. The boulder-clay bands often pass into gravels when traced along their outcrop. Glacial deposits.

At Paul's Branch, the river approaches the mountains on the east, and an opportunity was afforded for a short trip inland. Paul's Branch enters the Finlay through a deep narrow cañon, cut through the hard rocks of the outer range. Farther back, its valley becomes enlarged, and the stream soon splits up into several tributaries which wind through the wide marsh-filled valleys separating the hills and ridges of the district. Paul's Branch.

The eastern range here, as elsewhere along the valley, consists of the limestones, gneisses and schists of the Shuswap series. A band of hard compact limestone outcrops at the water's edge, while further back, bands of mica-gneisses, lustrous mica-schists, hornblende-schists, and occasionally quartzose-schists, alternate across the range. These rocks all dip to the south-west at angles from 50° to 60°, and strike N. 73° W.

The Shuswap series has a width at Paul's Branch of two miles. It is succeeded towards the east by argillites calc-schists and limestones of Cambrian age, dipping in a south-west direction under the older rocks. The contact between the two formations is apparently a faulted one, the Shuswap series being thrust eastward over the younger formation. Width of band of Shuswap rocks.

The ridges forming the central part of the Rocky Mountain range were not examined closely, but, judging from their appearance and from the wash of the streams flowing from them, they are evidently composed of massive limestones, similar to those found in a corresponding position in other parts of the range. Rocks in central range.

From Paul's Branch to the Quadacha, a distance of ten miles, the Finlay follows the eastern bank of the valley, and occasional exposures of the schists of the Shuswap series occur. A short distance below the mouth of the Quadacha, Laramie conglomerates outcrop on the left bank.

At the Quadacha, the Finlay bends to the west and soon after leaves the great valley which it has occupied from its mouth to this point. The valley continues northward, and is occupied, after the Finlay abandons it, by the Tochieca a tributary.

Volcanic schists.

In crossing the valley Laramie rocks were seen in a couple of places, but below the mouth of the Tochieca these are replaced by green schists, probably sheared and altered volcanic rocks similar to those overlying the limestones in the Omenica district. These schists have the usual strike, but the dip is to the north-east at an angle of 40°. The green schists have a width of five miles. They form the first ridge through which the Finlay breaks after it leaves its old valley. Prairie Mountain, the part of the ridge abutting on the Finlay from the north, was examined, and found to consist of green schists, often strongly chloritic, holding numerous stringers of quartz alternating with bands of yellowish weathering dolomites. Three bands of the latter were observed and four of the former. The strike of these beds is N. 30° E. and the dip is to the north-west.

Glacial striation or grooving were carefully looked for in ascending Prairie Mountain, but no trace of either was found.

After cutting through Prairie Mountain range, the Finlay enters and follows for some distance a second longitudinal valley running parallel to the first. Laramie sandstone and conglomerates occur in this valley and probably extend southwards along it to its junction with the main valley, a few miles below Paul's Branch. The conglomerate in this valley consists in places largely of sub-angular limestone pebbles, often several inches in diameter, and is occasionally coloured red by iron.

Laramie rocks.

Limestones.

At the second valley, the green schists are replaced towards the west by limestones, alternating with dark, glossy calc-schists, sericite-schists and argillites, evidently a continuation of the same band which forms the mountains bordering the Finlay valley on the west at the Deserters' Cañon, and for some distance above.

The band of limestones and associated rocks has a width of five miles. The thickness was not ascertained, as the dips are very irregular, the beds being overturned in many places. At the western edge of the band the prevalent dip is to the north-west.

Cambrian conglomerates.

The limestones are underlain by fine-grained conglomerates, interbedded with some quartzites and schists. The conglomerate is of Cambrian age, and like similar occurrences elsewhere, consists mostly of quartz and felspar pebbles inclosed in a hard siliceous matrix. It strikes in a north-west direction and dips to the north-east. The conglomerates are succeeded, in descending order, by mica-schists, mica-gneisses, hornblende-schists, etc., of the Shuswap series. The latter are exposed along the Finlay River from the mouth of the Thudaca River, westward to the expanded portion of the river at the Fishing

Lakes. Above this point the river enters an old alluvium-filled basin, and exposures cease. East of the valley, which here runs almost directly north-and-south, the mountains are built of the schists of the Shuswap series, while west of the valley an area of eruptive rocks occurs. The latter consist of diorites around the periphery, but soon pass to the west into biotite- and hornblende-granites. The dip of the schists is to the north-east, or away from the eruptive area.

The rock section exposed along the Finlay, after the latter leaves the valley bounding the Rocky Mountains on the west, consists of the western half of a great anticline, which includes the schists of the Shuswap series (Archæan), conglomerates and limestones of Cambrian age (Bow River and Castle Mountain groups), and an upper schistose series consisting of altered volcanic rocks, the age of which was not determined. Finlay section.

The dip of these rocks is usually to the north-east, but in places, and more especially in the limestone series, overturns have been produced by pressure from the west, and the dip is reversed.

The eastern limb of the anticline has entirely disappeared, a result probably affected by faulting along the line of the Finlay Valley. The junction between the volcanic schists at the summit of the Palæozoic section, and the Shuswap series east of the Finlay Valley, over which they are apparently faulted, is concealed by the Laramie conglomerates. Faulted anticline

*Section in Peace River Pass.**

A short trip was made through the Peace River Pass of the Rocky Mountains, for the purpose of obtaining a general view of the structure of the range in this latitude. The time occupied, one day in descending, and two days in ascending the river, was too limited for anything but a hurried reconnaissance. Peace River Pass section.

Peace River breaks through the Rocky Mountains, here about eighteen miles wide, in a direction a few degrees south of east. In its passage of the range it has a width of from three to five hundred yards. Its course, with the exception of two small rapids, one before entering and the other after leaving the range, is uninterrupted. The current seldom exceeds five miles an hour and for most of the distance is much less. The valley averages about a mile in width, and the bordering mountains range in height from 2000 to 4500 feet above the river, or 4000 to 6500 feet above sea-level. Character of river.

* See also Report of Progress, Geol. Surv., Can., 1875-76, pp. 41, 80.

Predominance of limestone.

The rocks exposed along the pass consist principally of grayish Palæozoic limestones striking in a north-westerly direction, and dipping persistently to the south-west. Repetitions of parts of the limestone series, caused by overthrust faults, occur at several points. No infolds of Cretaceous or Laramic strata, such as occur in Alberta, exist, and to this fact is due the greater irregularity of the subordinate ranges.

Cretaceous sandstone.

Immediately east of the main range, exposures of yellowish-weathering calcareous sandstone, probably of Cretaceous age, occur in the banks of the river. These are replaced, going westward, by grayish limestones dipping steeply to the west. The junction between the limestone and sandstone is concealed in the valley, but there is little doubt, from the relative position of the two formations, that the contact is a faulted one and that the Palæozoic limestones of the mountains, here as elsewhere along the eastern boundary of the range, are thrust up over the Mesozoic rocks of the foot-hills.

Fossiliferous limestone.

The limestones are fossiliferous, the fauna, so far as ascertained, being similar to the Banff or Devono-Carboniferous division of the Bow River section.

Triassic beds.

West of the fault, the limestones stand at a steep angle, the beds being fairly regular, but further west they become greatly confused and show evidence of much disturbance. In the second range, the limestones are overlain by a band of dark *Monotis*-bearing calcareous shales and impure limestones of Triassic age. West of the Triassic band, a second fault brings the Banff limestones again to the surface, and the same limestones, probably repeated by faults, occur in the next two ranges. In the first of these, the Banff limestones and overlying Triassic beds have a regular westerly dip, but in the second, a line of strong disturbance is reached, and the strata as seen on the mountain sides are crushed into numerous subordinate folds.

Fault.

A fault of considerable magnitude crosses the valley west of the two ridges referred to above, and brings up limestones which were referred to the Castle Mountain group. West of this fault, the dips north of the river for some distance were too confused to follow, but south of the river, the beds, with the exception of one double fold, dip regularly westward until near Mount Selwyn. The limestones in this part of the range are mostly unfossiliferous and of the Castle Mountain type, but higher beds holding *Halysites* were found in one place.

Mount Selwyn shows a sharp anticline on its eastern slope. The centre of the mountain is formed of almost vertical limestone beds, but going westward these are soon replaced by the quartzites, schists and crushed conglomerates of the Bow River series. The latter are forced

up over the limestones by a well-defined overthrust fault, running in a north-westerly direction.

Structure of Mt. Selwyn.

Mount Selwyn is flanked on the west by a small range composed partly of the rocks of the Bow River series and partly of the schists of the still older Shuswap series, all dipping to the south-west. The latter overlie the former, but the cause of their superior position was not ascertained.

Comparison with Bow River section.

The Peace River section through the Rocky Mountains, thus resembles the Bow River section through the same range, in the predominance of limestones and in the persistent westerly dips due to repetition of the beds by overthrust faulting, but differs from it in its absence of beds newer than the Triassic, and in the gradually increasing age of the rocks from east to west.

Geological Summary.

Archæan (Shuswap Series).

Shuswap series.

The oldest rocks in the district consist of a series of well foliated mica-gneisses, probably derived to a large extent from sheared eruptives, lustrous mica-schists, horneblende- and actinolite-schists, quartzose schists and crystalline limestones, filled with mica, hornblende and other secondary minerals. The rocks of this series are usually evenly bedded and conform in dip with the overlying formations.

Distribution.

Rocks of the Shuswap series are found on both sides of the Finlay from its mouth up to its junction with the Ingenica. North of this point, the formation divides around a bay filled with newer rocks. The eastern limb follows the eastern slope of the Finlay Valley north-westward to the Quadacha and for some distance beyond. It has a width at Paul's Branch, where it forms the most westerly range of the Rocky Mountains, of four miles. This width decreases towards the north and increases to the south.

The western limb bends away from the Finlay above the Ingenica, but crosses it again at the great bend which the Finlay describes after leaving the Rocky Mountains, and continues on to the north. The width of this band was not ascertained, as its western boundary was not reached.

A second area of Shuswap rocks, separated from the first by a band of limestones, occurs on the Omenica River above the Oslinca. The gneisses in this occurrence are coarser in grain than is usually the case, and in places have a granitic appearance. The band has a width of ten miles.

Lower Palæozoic.

Clastic rocks overlying Shuswap series.

The Shuswap series is overlain on the Omenica by a band of slates, quartzites and conglomerates similar in lithological character and in geological position to the Bow River series of the Bow River section; and like it, probably referable to the Lower and Middle Cambrian. The conglomerates have an arkose appearance, and consist principally of small rounded quartz and felspar pebbles interbedded in a hard siliceous matrix. Fragments of schist and slate are also occasionally included. A purplish coloration of many of the quartz grains characterizes the conglomerates of this formation wherever found, from Bow River north to the Finlay. The conglomerates and associated rocks on the Omenica have a thickness of about 4000 feet.

A band of conglomerates and schists, referable to the Bow River series, also occur on the Finlay below the mouth of the Thudaca. These rocks overlie the Shuswap series and are similar in most respects to the Omenica occurrence. The conglomerates are greatly crushed in places, and often assume a schistose appearance from the development of secondary mica parallel to the cleavage planes.

A third band, similar in character to the others, forms part of the western slope of Mount Selwyn.

Castle Mountain group.

The conglomeratic bands are everywhere overlain by a great limestone formation, corresponding to the Castle Mountain group of the Bow River section, and like it, probably ranging in age from Middle Cambrian up to Cambro-Silurian. The limestones are grayish in colour, except where whitened along lines of disturbance, and are usually evenly bedded, but in places, especially when impure, pass into a calc-schist. No fossils were obtained from them.

Distribution.

Limestones of this group are found all along the western portion of the Peace River section through the Rocky Mountains east of Mount Selwyn, and extend northward along the range as far as examined. West of the Rocky Mountains they occur in bands of from four to eight miles in width, running in a north-westerly direction. One of these bands crosses the Finlay at its bend and extends south to the Ingenica where it is cut off, and two others cross the Omenica above the Tchutetzeca.

The limestone rests normally on the Bow River conglomerates, but in many places in the district the latter are absent, either from non-deposition or in consequence of faulting, and the limestone comes in direct contact with the Shuswap rocks.

Upper Palæozoic.

Grayish well-bedded limestones, holding corals, brachiopods and other fossils characteristic of the Banff or Devono-Carboniferous division of the Bow River section, occur in the eastern ranges of the Rocky Mountains, while near the centre of the range, lower beds probably Silurian in age, holding *Halysitis catenulatus*, were found in one place. Banff limestones.

The volcanic schists and associated rocks exposed along the Omenica from below Germansen Landing to near Tacla Lake, are probably upper Palæozoic, but no definite evidence of age was obtained, beyond the fact that they overlie the limestones referred to the Castle Mountain group and underlie the probably Cretaceous conglomerates of Tacla Lake. The band of green schists which crosses the Finlay above the mouth of the Quadacha occupies a similar position. Volcanic schists.

The schists are greenish in colour and are well foliated, as a rule, but in places the bedding becomes indistinct, and the rock assumes a very massive character. The transition is nowhere abrupt, and probably indicates a gradual passage from a volcanic centre, usually diabasic in character, outwards to tuffaceous and well stratified ash rocks.

The volcanic schists are interbedded with argillites, and occasionally with beds of limestone and dolomite.

Mesozoic.

Triassic beds, consisting of dark calcareous shales passing into an impure limestone, occur in the second range of the Rocky Mountains, and a band of similar rocks forming part of the third range may possibly belong to the same foundation. Specimens of *Monotis subcircularis* are abundant in the first-mentioned locality. Triassic beds.

Cretaceous beds occur in the foot-hills, but were not recognized in the mountains. The conglomerate and sandstones found in the valley of Tacla Lake resemble Cretaceous rocks found elsewhere in the province, but no direct proof of their age was obtained. Cretaceous beds.

Tertiary (Upper Laramie).

Beds consisting of conglomerates, interbedded in places with shales and sandstones, occupy the bottom of the valley of the Finlay from the Ingenica River north to the Tochieca, and continue northwards along the valley of the latter stream. Similar beds appear again on Laramie.

the Finlay a few miles farther west in a parallel longitudinal valley, which it enters and follows for some distance. They are also found on the Omenica from the Black Cañon up to its junction with the Tchutetzeca.

The pebbles of the conglomerate are usually small, but in places are several inches in diameter. They consist mainly of slate, quartz, and limestone. Oxide of iron is occasionally present in the matrix in sufficient quantities to give a reddish coloration to exposures. The shales are dark in colour, are evenly bedded, and are interstratified in places with small lignite seams. The sandstones are usually somewhat argillaceous, and occasionally consist largely of mica derived from the disintegration of the underlying schists.

Distribution of Laramie.

The Tertiary conglomerates and associated rocks, as stated on a previous page, are distributed in narrow strips along the deep valleys of the district and were nowhere found on the highlands. They were probably deposited in lakes during a Tertiary depression, and evidence the pre-Tertiary age of the present main river-channels. The conglomerates are occasionally horizontal or nearly so, but in most cases they are tilted at angles ranging from 10° to 40°, showing that they have been affected to some extent by the later mountain-making movements.

Some leaves and other plant remains, obtained from the shales interbedded with the conglomerates, were examined by Sir J. Wm. Dawson, who has kindly furnished the following note on them :—

"The collection is small, and the specimens imperfect, more especially in respect to the finer venation and margins of leaves. The following forms were recognized :—

Fossils.

"*Arundo.*—A ribbed stem possibly of this genus. Omenica River.

"*Sequoia.*—Plentiful in Finlay River shales ; appears to be *S. Langsdorffii*. On the black flags from Omenica River there is another form, which may be distinct, and shows curious terminal buds. There are also branchlets referable to *S. Couttsiæ*.

"*Populus.*—A leaf of the type of *P. Arctica*, Heer, *P. Nebrascensis*, Newberry, and *P. speciosa*, Ward, if these are really distinct. Omenica River.

"*Platanus.*—Possibly *P. Haydenii*, Lesquereux, or allied species. Omenica River.

"*Quercus.*—A fragment possibly of this genus. Omenica River.

"*Grewia* or *Grewiopsis.*—This is a genus allied to *Tilia*. A single imperfect leaf may represent it. Finlay River.

"*Viburnum.*—Apparently *V. aspera*, Newberry, or near to it.

"*Carpolite.*—A single imperfect specimen resembling *Legumenosites arachnoides* of Lesquereux.

"*Animal Fossils.*—Minute bivalve shells of two kinds, one possibly an *Estheria*, another perhaps a *Cyprid.*

"All the above fossils, so far as determinable, appear to indicate the Upper Laramie period. Of the collections in my possession, the plants seem most nearly to resemble those of the Lignitic series on the Mackenzie River, which are referable to the Upper Laramie. There is nothing among the plants to indicate any other horizon."

Pleistocene

Evidences of glaciation abound throughout the district. In the Peace River Pass, well-marked glacial groovings occur on the south side of the river two miles east of Mount Selwyn. The movement of the ice here was eastward. Glacial groovings of a pronounced character, running in an easterly direction, were observed on the hillsides north of the Omenica River twelve miles above Germansen Landing, and they are also reported to occur on the summit of a mountain south of Manson Creek at an elevation of 5000 feet above the sea. No groovings were found along the Finlay, but the exposures on the mountain slopes north-east of Fort Grahame present in many instances the smooth rounded characters of rocks polished by moving ice. The movement here was in a south-easterly direction. Glacial groovings.

The glacial deposits consist of boulder-clay, accompanied by gravels, sands and silts.

In Peace River Pass, gravels, sands, and silts of glacial age are of constant occurrence, and boulder-clay holding striated stones occurs in a couple of places. On the Omenica River, a high bank of stratified sands, silts and gravels occurs below the Black Cañon, and boulder-clay accompanied with sand and gravel was found above the mouth of the Oslinca. Below Germansen Landing, light-colouring silts weathering into steep bluffs are exposed for several miles along the valley. From Germansen Landing to Hogem the immediate shores of the river are low and are mostly built of alluvium. Glacial deposits.

Boulder-clay is developed to a greater extent on some of the tributaries of the Omenica than on the river itself. High banks of this material occur on Germansen Creek and on Manson Creek, and in both cases are underlain by fluvio-glacial gravels, which are often auriferous. Boulder-clay banks of considerable thickness were also found on Vital Creek and on Tom's Creek.

Morainic hills.

Morainic hills, among which small lakes are interspersed, occur near the summit of the pass leading from Tom's Creek to Tacla Lake.

Boulder-clay banks.

On the Finlay River, boulder-clay is scarce below Deserter's Cañon. The river in this stretch is bordered for long distances by banks of alluvial clays and sands, and where the higher terraces are cut into, the sections show, as a rule, only the upper stratified sands and silts. From Deserters' Cañon to the bend of the Finlay, boulder-clay banks, some of which are 225 feet in height, are frequent. The boulder-clay here is often imperfectly stratified and often passes horizontally into gravel beds. Striated stones are common, but the majority of the pebbles are water-worn to a varying extent. No boulder-clay was noticed on the Finlay above its bend, the banks usually consisting of rolled gravels overlying the older rocks in the swifter portions of the stream, and of alluvial clays and sands where the current becomes sluggish.

Terrasce.

Terraces were observed at a number of places. Along Peace River Pass they occur up to a height of about 400 feet and on the Omenica below the mouth of the Oslinca, up to a height of 250 feet. On the Finlay, north-east of Fort Grahame, rolled gravels and traces of terraces easily distinguishable at a distance, occur up to a height of 2000 feet above the river. High terraces were also noticed lining the sides of the mountains at the Fishing Lakes. A well-marked terrace, built of silty clay and gravel, occurs here at a height of 1250 feet above the river or 4500 feet above the sea, and others less distinct were found up to a height of 1950 feet above the river.

Glacial succession.

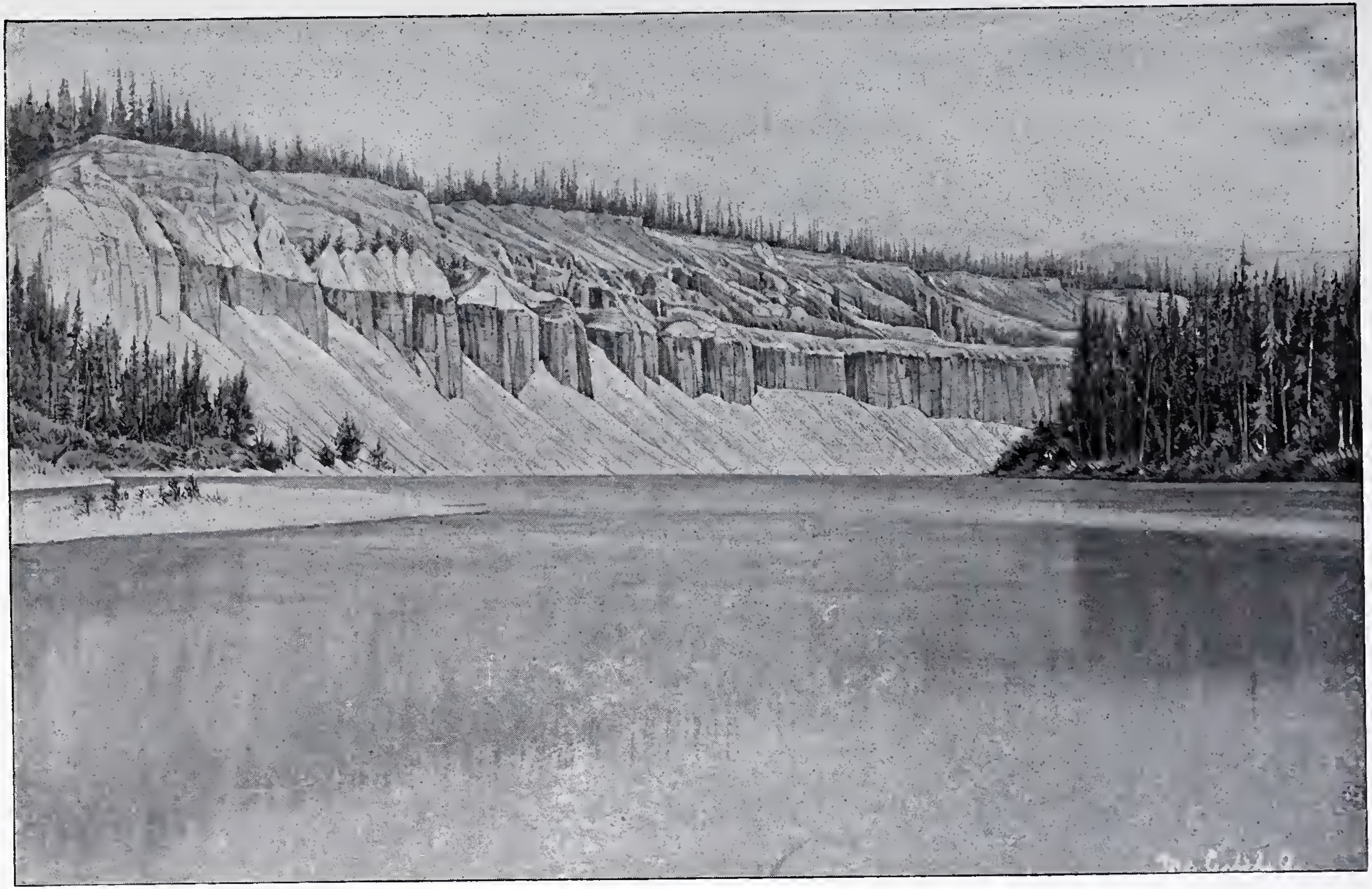
The glacial succession, when fully developed, consists in ascending order of gravels, associated in places with stratified sands and silts; boulder-clays holding occasional pebble beds; stratified sands, clays and gravels ; and terraces. The position of the light coloured silts on the Omenica, below Germansen Landing, was not ascertained, as their contact with the other members of the glacial section is concealed.

The alluvium-filled rock-basins which the Finlay enters six miles above the Thudaca, and the Omenica, near Slate Creek, probably owe their origin to recent differential crustal movements.

Economic Notes.

Discoveries of gold.

The first discovery of gold in the Peace River country was made on the Parsnip, about 20 miles above its mouth, by Bill Cust, in 1861. In the following year Pete Toy's bar on the Finlay, a few miles below the Omenica was found, and for some time proved wonderfully productive, the yield amounting to about \$50 per day to the man. Silver



R. G. McConnell, Photo., Aug., 1893.

GLACIAL BEDS, FINLAY RIVER.

Creek, a tributary of the Omenica, was found in 1868, and Vital Creek, a branch of the former, in 1869. In 1870, diggings were found on Germansen Creek and the following year on Slate, Manson and Lost Creeks. No further discoveries were made until Tom's Creek was struck in 1889.

The population of the country reached its maximum about 1872, and has since steadily declined. In 1893 four miners were working on Germansen Creek, eight on Manson Creek, three on Vital Creek and about twenty on Tom's Creek. The other creeks have been worked out and deserted. Population.

The total production of the camp up to the present time, judging from the fragmentary statistics of the district published in the Annual Reports of Minister of Mines for British Columbia, and from other sources, probably approaches closely to, if it does not exceed, a million dollars. Production.

The gold in the Omenica region has been obtained principally from the gravels overlying the older rocks, in the beds of the present streams. The gravels, as a rule, have little depth, and the productive portions of the different streams seldom exceed three miles in length. No deep diggings or extensive hydraulic workings have so far been attempted in the district. Auriferous stream gravels.

The auriferous gravels underlying the boulder-clay on Germansen, Manson and other creeks in the district have a wide distribution and promise favourable results if worked on a sufficiently large scale. A short tunnel was driven into a bank of this description on Germansen Creek by Mr. Clinton in 1892, and sufficient gold taken out to pay small wages. Water can be obtained almost anywhere from lakes and mountain streams, within a reasonable distance, and the only drawback to successful hydraulic mining is the great expense attendant on the carriage of material and supplies from the coast. The absence of easily navigable waterways, and the mountainous and swampy character of the surrounding country, present obstacles to transportion which can only be overcome at great expense. At the present time, the greater part of the supplies are brought in by pack animals from Hazleton at the Forks of the Skeena, the rate to Manson Creek amounting to 17 cents per pound. Auriferou glacial gravels. Transportation.

Some prospecting has been done in the Omenica region every season since its auriferous character became known, but the district has by no means been thoroughly explored. The discovery of pay gravels on Tom's Creek, close to Vital Creek, twenty years after the later was found, shows how loose the examination has been, nor need this be Prospecting

wondered at when the short seasons, difficult travelling and high prices of supplies are taken into account. That further discoveries of auriferous creeks will be made admits of little doubt.

Gold on the Finlay.

Fine gold occurs on the Finlay throughout most of its course, but with the exception of Pete Toy's bar, previously referred to, no paying placers have been discovered. Very little prospecting has, however, been done on this stream, and with the exception of the Ospica, none of the tributaries, so far as I could learn, have ever been prospected. Gold, mostly in a fine condition, was found in ascending the river, at the mouths of the Ingenica, the Quadacha, and the Tochieca, and also on two of the smaller western tributaries, one of which enters the Finlay eight miles below Paul's Branch, and the other six miles above the Tochieca. With the exception of the Quadacha no "colours" were found on the eastern or Rocky Mountain streams above Deserters' Cañon.

Galena veins

No ore mining has so far been attempted in the Omenica region owing to the want of transportation facilities, although the existence of large veins of highly argentiferous galena has been known for many years.* Arquerite or silver-amalgam is also of common occurrence in the placer diggings on Silver Creek, and on Vital and Tom's Creek, two of its tributaries. The two latter streams are of little length, and a systematic examination of their basins could be made at small expense.

Occurrence of gold.

The gold in the Omenica district occurs in a coarse condition, nuggets often being found with quartz still attached to them, and is evidently derived from the band of green schists and argillites previously described which outcrops along the Omenica and its tributaries from below Germansen Landing west nearly to Tacla Lake. All the auriferous creeks worked up to the present are situated within this zone, which has a width of forty-eight miles. The schists, of which it is formed, are everywhere much disturbed, are broken up by intrusions of granitic and other eruptive rocks, and present in this and other ways promising indications that they are metalliferous in character

Rocks probably metalliferous.

*Report of Progress, Geol. Surv. Can., 1879-80, p. 111 B.

GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

REPORT

ON THE

COUNTRY IN THE VICINITY OF

RED LAKE

AND PART OF THE

BASIN OF BERENS RIVER

KEEWATIN

BY
D. B. DOWLING, B. Ap. Sc.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY
1896

To George M. Dawson, C.M.G., D.S., F.G.S.,

Director Geological Survey of Canada.

Sir,—I beg to present herewith a report on the country explored during four months of the summer of 1893. It is necessarily of a preliminary character, as the exploration was intended as the commencement of further examinations of the area lying between Lac Seul and the Berens River, and from Cat Lake westward to the Winnipeg map-sheet.

No published maps of this district give more than rough sketches of any of its details, and the geological features have been previously known only from cursory explorations.

The map accompanying this report is compiled from careful log-surveys of the lakes and estimated traverses of the streams, checked by latitude observations. The base to which the whole is referred, is founded on a micrometer and transit survey of the English River made by Mr. Thos. Fawcett, D.T.S., in the summer of 1885.

I was assisted during the above period by Mr. J. C. Gwillim, then a student at McGill College, and to him are to be accredited the surveys of several of the smaller lakes shown on the map.

Besides showing many lakes and streams not hitherto mapped, the outlines of the Red Lake Huronian band, as well as part of the newly discovered Woman Lake Huronian area, are indicated, and these areas are briefly described.

I have the honour to be, sir,

Your obedient servant,

D. B. DOWLING.

NOTE.—*All the bearings mentioned in this Report are with reference to the true meridian.*

REPORT

ON THE

COUNTRY IN THE VICINITY OF RED LAKE AND PART OF THE BASIN OF BERENS RIVER, KEEWATIN.

The present report contains a summary of the results of an exploration undertaken during the summer of 1893, in the southern part of the district of Keewatin. The area comprised in the report lies just to the east of the eastern boundary of Manitoba and north of the Province of Ontario. It extends from the English River and Lac Seul, northwards to Berens River, the eastern branch of which forms approximately, the northern limit of the area. To the east, the exploration includes the heads of streams flowing eastward to Cat Lake, and on the west the White River, a southern branch of Berens River, with the western end of Red Lake, confine its extent in that direction. Area covered.

The map which illustrates the area, shows it to be situated between latitude 50° 30′ N., and 51° 50′ N., and between longitude 92° 40′ and 94° 15′ west of Greenwich, an area of 6300 square miles.

A sketch map*, showing the position of this area and its principal streams and lakes accompanies the Summary Report of the Geological Survey for 1893, in which is also a brief description of the routes followed.

Physical Features.

The larger part of the area forms a basin draining to the south to English River, and thence to Lake Winnipeg. In this are situated the largest lakes of the district, comprising Red Lake, Trout Lake, Gull Rock Lake, and Shallow Lake. The northern portion drains northward to Berens River and thence westward to Lake Winnipeg. Drainage basins.

A small area containing a few lakes on the east side, is found to drain to the eastward, forming a part of the Albany River basin, which empties into Hudson Bay.

*Annual Report, Geol. Surv. Can., vol. VI. (N.S.) 1892-3, p. 22 A.

Southern Basin.

Southern or English River basin.

The basin drained by the streams flowing south to English River, is almost an amphitheatre in form, facing the south. The several streams converge to the convex line followed by the valley of the English River. The watershed forming the outer boundary or rim of this area, rises gradually from the west toward the east, having, probably, its highest point between the waters of Cat Lake River and Lac Seul. To the west, in the vicinity of Long-legged Lake, it rises to 1200 and 1300 feet, or sixty feet and upward above Lac Seul. North of Red Lake, the portage at the height-of-land to White River is at 1300 feet, while north of Trout Lake it is considerably higher, as this lake itself stands at nearly 1300 feet. The Woman Portage, between Shaboomene and Woman lakes, is estimated to be at 1350 feet above sea-level.

The general surface of all this basin, is of a rough, rocky character, with small areas between the ridges, of alluvial and glacial deposits. Across the north-eastern part, a strong ridge of glacial material forms a long and nearly straight line, through which two streams have cut. It is much more strongly marked near Trout Lake, and there clearly forms a dam, retaining the waters of that lake. All the other lakes are evidently in rock basins, surrounded by rocky hills.

The higher parts of the rocky country forming the remainder of the basin, show very little covering of drift material of any sort, except a few boulders, with sand in the valleys. North of the Trout Lake ridge, the most noticeable feature is the enormous number of boulders on the shore of the lake.

Topography of two classes.

Effect of geological conditions on the topography.—In general, that part of the country in which the surface is of gneiss and schist, is lumpy, with hills aligned in ridges, but the surface-level is more or less a sloping plane. In areas in which light-coloured intrusive granite prevails, the surface is, however, considerably raised above this plane. The Huronian areas here, as usual, show more pronounced denudation and greater irregularity in surface feature. The narrow, crooked lakes in the Woman Lake region, occupy gaps and gashes between high ridges. The high angle at which these rocks stand, admits of a greater disintegration of the softer beds, such as limestones and chloritic schists.

These areas can hardly be described as forming basins. The general surface of the country is apparently higher than elsewhere, but it contains deeper depressions, which are occupied by lakes. In tracing out the line of contact of the granite with the green Huronian schists of

Red Lake, it is found that nearly half the area of the lake is underlain by granite, so that this lake is not properly described as a basin in the Huronian rocks, though the greater part of its northern arms and bays are entirely within that area.

Trout Lake.

It will be noticed on reference to the map that, although the Huronian areas are evidently well sprinkled with lakes, still the largest basin of all, Trout Lake, is altogether beyond them and is most probably not a rock basin at all, the southern side being a dam of morainic material. The suggestion that this is the case arises from the fact that not only are there but one or two low rock-exposures along the northern foot of this ridge, but, that the lake lying only three or four miles to the south of Trout Lake, over this ridge, is estimated to be about one hundred and fifty feet below, and is fed by two small streams having their origin in the hills between, and carrying relatively more water than the small area they are supposed to drain, would naturally produce.

Heights of lakes in Southern basin.

Relative heights of lakes.—In order to obtain a relative scale of heights for the lakes and hills in the district, an estimate of all the various falls in the rivers and on portages was carried from the railway through to Berens River by both routes followed. The aneroid barometer was used on long portages and in measuring the height of hills.

The estimated heights above sea-level of the principal lakes in this area, obtained in the above manner, are as follows:—

	Feet.
Lac Seul	1140
English River at Mattawa	1105
Shallow Lake	1105
Little Shallow Lake	1106
Sand Bar Lake, English River	1035
Wilcox Lake, English River	1030
Long-legged Lake (Lower)	1173
Long-legged Lake (Upper)	1175
Gull Rock Lake	1146
Red Lake	1148
Little Red Lake, or Little Vermilion Lake	1173
Lake at height of land north of Red Lake	1250
Bug Lake, south of Red Lake	1266
Upper Medicine Stone Lake	1210
Lower Medicine Stone Lake	1200
Trout Lake	1295
Snake Lake	1270
Little Bear Lake	1310
Woman Lake	1315

	Feet.
Fly Lake	1356
Bluffy Lake	1220
Sha-boom-ene Lake, draining to Cat River	1330
Head of eastern branch Berens River	1350

Long-legged River.

Long-legged Lake and River.—A small stream enters the western end of Wilcox Lake, draining a series of closely connected lakes known collectively as Long-legged Lake. The lower part of the stream flows through low swampy country gradually rising to the west. The channel is wide and deep, with sluggish current, and the course is crooked, but with long bends. This character continues for five miles, where a fall of eighteen feet over a ledge of dark gneiss is reached. At the time of our visit (August 30), very little water was running, forming a thin veil the whole width of the ledge, but in high water it must be a fine fall. A portage of one hundred yards is on the east side.

The stream above the fall continues of about the same character, but flows through a sandy country with few rock exposures. The timber is mostly Banksian pine of small size. Between the falls and short rapids there is a very light current, so that it is easily navigated, except that in the upper part, near the lake, there are numerous short portages which take time to surmount. Two miles beyond the eighteen-foot fall, is another of twenty feet, with a portage of seventy yards, this is followed in a quarter of a mile by a fall of thirty feet, with a portage of one hundred yards.

From a short distance below this fall to near a small lake expansion two miles above, the borders of the river are fringed with rushes and wild rice, with sandy country behind covered by a close growth of slender Banksian pine. Occasionally, on lower ground small patches of spruce and tamarack occur, in which are seen a few trees over eighteen inches in diameter.

Sediment-filled basin.

The small lake which the river passes through has originally been a basin of two miles in length and a quarter of a mile in width, lying in a trough between gneiss ridges running east-and-west. The river-valley enters this basin on the middle of the northern side, and flows out at the eastern end. The sediment brought down and deposited by the river has formed a delta, by which the lake has been divided into two parts, separated by a low, marshy flat through which the river now winds in a very irregular course. The older part of the delta is higher ground and produces fine wild hay, while the immediate banks of the stream are lined by rows of ash and elm, as commonly found in Manitoba.

Upper part of river.

Above this lake the river bears north-westward, through level country, and in a mile turns westward, winding in the bottom of a low

flat valley or depression between higher ridges and knobs of gneiss. The stream passes near a high steep rock of gray gneiss, in vertical beds running to the west. The banks are clay, and on the north side of the valley half a mile east of the steep rock, the stream has cut into a hill which shows sixty feet of stratified clay.

The river now becomes irregular in its course to the outlet of the lake, descending in a distance of two miles over several ledges of gneiss, in falls and rapids, successively of 1 foot, 5 feet, 3 feet, 30 feet, and 3 feet, or aggregating seventy-two feet, at all of which short portages are necessary in low water, and in high water at five of them.

The lakes, forming a group at the head of this stream, are all of irregular shape, but generally lie north-east and south-west, or across the general direction of the drainage, following somewhat the strike of the rocks. Long bays run in the same direction on either side of the lakes. The ridges or hills of the surrounding country also mainly run with the strike of the gneiss.

Lower Long-legged lakes.

The first lake of the series is four miles long and one and a half wide. Two large islands are found in the northern half. A long narrows, of nearly two miles, connects this with the second, which is of the same length in a north-east and south-west direction, but a mile wider, having few islands in the central portion but a number scattered along the shores. A crooked narrow lake, running from the western side towards the north, and then turning west, brings us to the north end of a small lake terminating at the south end in three long finger-like bays. On the north western side, at an opening leading to a small lake, we find a swift current with a fall of a foot over gneiss rock. Here the Indians have constructed a fishing weir or dam, to which they resort in the autumn. After crossing a small bay or lake expansion, half a mile in diameter, a narrow opening admits to the upper or most western lake of this series.

Upper lake.

This is the largest of the Long-legged lakes, but still is of no very great extent. It might be called a rectangle in shape, with one diagonal running east-and-west and having sides of three miles each. The river leaves by the eastern end, just north of which runs a narrow arm of a mile and a half in length to the north-east. At the south end, a short bay breaks the regularity of the shore, but at the west end there are two bays, the one forming a small lake with a narrow entrance. This bay is a mile in diameter, while the one on the north is smaller and likewise nearly cut off from the main lake. The islands are mostly narrow ridges of gneiss running north-east and south-west. The hills surrounding this western lake are much higher than to the east, and it appears to be at

the extreme western limit of the watershed. A stream enters the west bay, but it is a very small one fed by two or three large muskegs and small lakes lying immediately behind the first ridge, west of which again higher ridges are seen.

We climbed several hills to the west of these two bays and found them to be principally composed of horizontal beds of gneiss, broken and fissured by large dykes of pinkish granite. The most western hill was almost entirely granite, sending out wide dykes of pinkish coloured granites through the broken gneiss to the eastward.

Mattawa River.

Mattawa River.—The largest stream joining the English River on the north side, below Lac Seul, is the Mattawa. This enters at what was formerly an Indian reserve, but where there is now only a Hudson's Bay Company's trading post called Mattawa. The river to which the name applies, is but a short strip of sluggish water connecting the English River and Shallow Lake. Above this there are two streams whose waters discharge by the Mattawa. The Trout Lake River empties into Little Shallow Lake lying to the east and thence flows to the north-east corner of Shallow Lake. At the extreme northern end of this lake is found the mouth of Red Lake River. These two are both fair sized streams, so that the flow of water in the Mattawa is considerable, but, owing to the large size of the channel, the current is very slight. From the river to the lake, a distance of four miles and a half, this strip of water occupies a wide valley enlarged into lake-like expansions, which apparently often serves as an overflow channel from the English River, at times of high water. As an example, during the summer of 1893, between June 30th and July 17th, the waters in the Shallow lakes and English River at Mattawa rose six feet; this rise was not occasioned by increased flow in the Trout Lake and Red Lake rivers, but altogether to the increase of volume in the English River, showing that the formation of the large channel of the Mattawa has been aided by the ebb and flow from freshets on the English River.

Occasional reversal of flow.

This channel is cut through soft stratified beds of sand and clay which occupy the lower country between the hills. The English River, below the junction, is held back by a rocky barrier of gneiss, which striking to the west, forms ridges running generally in that direction.

Shallow Lake.

Shallow Lake.—Shallow Lake is a long narrow strip of water, ten miles in length, lying north-and-south. From the south-western angle, a narrow arm runs westward about two miles, widening out and terminating in a round bay containing two small islands. In the main

body of the lake, a number of islands are scattered in irregular order, numbering in the aggregate about thirty.

The shores of the eastern side are in general of easy slope, the country behind rising gradually to the high land lying north of English River. The narrow strip separating the two Shallow lakes is generally low, but rises in a high narrow ridge to the north, which, with a similar one lying to the west, but starting from the north end of Shallow Lake, forms a valley. Through this the waters draining into the smaller lake reach Shallow Lake, in a wide sluggish stream bordered for the most part by grassy and rush-grown flats with a fringe of small willow bushes. Its shores.

The same gap or valley continues to the north-east, and down it a small stream flows. A continuation of the eastern ridge which forms a prominent point just west of the mouth of Trout Lake River, parallels the course of that stream for some distance.

The low-lying country on the east and south-east of these two lakes is found to be underlain by gray gneiss, while the change to steeper slopes and higher hills running parallel to the shores on the south and west, is principally due to the change in the character of the rocks. Those on the west are mainly a series of fine-grained dark gneisses.

Lying across the mouth of the valley of Red Lake River, are two prominent hills, which on examination were found to be morainic, or of glacial origin. These are very noticeable and are seen for a long distance down the lake.

Red Lake River.—This stream empties into a bay at the north end of Shallow Lake. A short rapid or fall, of a foot or more, is found at its mouth caused, by a ledge of dark fine-grained, rusty, green slate or schist. In high water in the lake, this rapid is drowned out. Red Lake River.

Above this, the river makes a long bend to the west, to the north of the prominent hills just mentioned. The hills take the form of narrow ridges, of no great length, lying west-south-west, and east-north-east, with an altitude of one hundred and seventy feet above Shallow Lake. The slopes are thickly wooded with small Banksian pine and spruce. The sides of the hill show no rock in place, but everywhere pebbles and boulders of loose rock are seen. The material of the hill is apparently a mass of fairly well rounded pebbles and boulders, with sand and gravel filling the interstices. On the southern slope large blocks and angular boulders are occasionally seen on the surface. Most of this material is of grayish gneiss and granite with a few scattered pieces of the green felsites and schists of the Huronian. Morainic hills.

Falls.

Northward, the river passes through a low strip of country gradually rising, and at a mile and a half the banks are twenty to thirty feet above the water. Here the first heavy fall occurs, caused by a band of dark schists. The portage past this, leads up a steep bank of clay and sand on the west side, to thirty feet above the river, and along a level terrace, descending with a more easy slope to the river above. The distance is 250 yards, and the fall in the river fifteen feet.

At about half a mile above this, there is another small fall of ten feet. Although rock in place is seen at the foot of the fall, the obstruction seem to be occasioned by a great accumulation of boulders, and in the river, just above, large angular boulders of granite nearly fill the channel. Their presence is accounted for by the fact that the river here cuts through a ridge of morainic material, which is seen to be a spur from a high ridge running off to the north-east. The portage is on the east side, and is one hundred yards long.

Farther up, the stream is wide and has little current to the next fall, the general course being to the north-west, but including a long curve to the south. Here an accumulation of boulders in the bed of the stream causes a rapid with a fall of twelve feet, to pass which there is a portage road of 170 yards on the west side.

The upper part of the river to Gull Rock Lake, is a succession of small lake-stretches, with a wide river-channel connecting them, in which the current is appreciable in one place only, where there is a hollow bar.

Timber.

The timber on the banks is mostly poplar of a fair size with a sprinkling of birch and black spruce. The birch average twelve inches in diameter, but only a few of the spruce trees were found over eighteen inches.

Just to the east of Gull Rock Lake, a small lake-expansion of less than two miles in diameter is crossed. On this a light granite with slight foliation is seen, and the same rock is probably to be found on the river below, though no exposures were met with.

Gull Rock Lake.

Gull Rock Lake.—This lake, which lies immediately to the east of Red Lake, with its longest diameter north-and-south, has a total length of eight miles.. The inlet and outlet are on the south-west and south-east sides respectively. The northern part is narrow, but towards the south the lake widens out to four miles. A string of islands runs across south of the middle, and others are scattered along the eastern and southern shores. To the south, the shores are high and bold, but to the north more gradual slopes prevail, while on the western side

one bold hill of granite is conspicuous. A small creek at the north end, leads to another lake of three miles in extent, occupying the same trough, beyond which is a high ridge separating these waters from Trout Lake.

A deep channel joins Gull Rock Lake with the western end of a small lake called Keg Lake, lying to the north-west, and a short portage connects the two, saving about three miles of travel by the river.

Red Lake.—About three miles west of Keg Lake by the river, is the entrance to Red Lake. No idea of its size or shape can be formed on inspection, as from the great number of islands and the irregular shape of its shores no great view of any extent of water is seen, and it is only by traversing the whole of its shores that its area can be appreciated. The largest open part is that which is entered first. From this to the west, extends a long narrow arm, which contracts in several places to less than a quarter of a mile. At the western end, a narrow, crooked channel connects with what is called Pipestone Bay, a small expansion of two miles in diameter, where the Indians obtain stone for making pipes. This is a soft compact chlorite and the pieces they use are from loose boulders, though the rock was seen in place in a thin band, in the narrows. Red Lake. Pipestone Bay.

An arm or long bay runs to the north-east from the main body of the lake, and connects by a narrows with a long lake lying about parallel to its course, on the east, joining it at about two miles from its northern end. This addition is about six miles long and less than a mile wide, and lies in a trough in the Huronian, the shores following in the main the strike of the rocks. East Bay.

The total distance from the extreme north-eastern end of this bay to the western end of Pipestone Bay, is twenty-seven miles in a west-south-west direction. At right angles to this, the greatest breadth, which is from the outlet northward to the end of a bay on the north side, is roughly seven miles. Size of lake.

The forest about this lake is somewhat varied, spruce and Banksian pine alternating as the dominant trees. On all the dry and sandy ground a thick growth of slender Banksian pine is found, and no trees of large size are apparently to be seen in such areas; but in the valleys and near the lakes, black spruce is occasionally met with, forming small groves scattered through the forests of deciduous trees. Individual trees of larger size are common on the islands and points over which forest fires have not run, and such trees may attain in some instances a diameter of twenty inches, but the average is under eighteen inches. Forest.

Birch and poplar are almost always present wherever the soil admits. On the richer and lower ground, between Red Lake and Gull Rock Lake, and farther down the river, the poplar trees are well grown and appear in groves in which nearly all the trees average eighteen inches in diameter near the base. Farther to the westward on the higher ground, the soil being sandy, the Banksian pine is more abundant, and near the western end of Pipestone Bay, some trees of red pine form a small grove, which appears to be the northern limit of the species in this basin.

Tributaries.

Streams flowing to the Red Lake basin.—The streams flowing from the south to Gull Rock Lake and Red Lake are all rather small. The first one examined was a small stream draining Stone Lake, and emptying into the south bay of Gull Rock Lake. This proved to be very shallow, and the lake is of small size lying between hills of granite, with occasionally fragments of Huronian rock caught up in it, showing at a few points on the lake.

Stream from Bug Lake.

Another lake lying further to the west, called Bug Lake, drains by a small creek to the western extremity of the south bay of Gull Rock Lake. The valley in which this lake and stream lie, runs west by south-west from Gull Rock Lake, following the strike of the gneisses and altered rocks. The distance from lake to lake by the river is about four miles, with two miles of the western part over a lake connected with Bug Lake by a short reach of sluggish river. The upper part of the stream is very shallow and is overhung by tall gray willow bushes, making travelling along it difficult. Two portages were made past rapids. The fall at the lower one is seventy feet and at the next forty feet, so that the lake lies at an elevation of about one hundred and twenty feet above Gull Rock Lake.

From a bay on the south-west, a portage leads to a small lake draining to Red Lake. The road is through scrub pine bush with mossy floor, over a slight rise for about 600 yards—the terminal points being at about the same elevation.

Stream from Medicine Stone Lakes.

The stream which rises here flows through several large lakes, and reaches Red Lake about a mile east of a narrows near the middle of the lake (Middle Narrows). The small lake at the head waters is bordered by mossy muskeg, and is about one-third of a mile in length. The stream flowing from its western end is too small for canoes, and the portage to the next lake is through spruce bush for 1000 yards. The fall is about fifty feet to a lake less than half a mile in length. Two small portages and an intervening pond, lie between this and the Upper Medicine Stone Lake, which is a long narrow strip of water

running to the south-west. Its total length is six miles, with a breadth averaging half a mile. The north-west shore is bold and is of granite, while the south-east is lower and shows fewer exposures, principally altered rocks and dark-green eruptives, with granite in a few places. Between the points the shores are mostly of angular boulders. Upper Medicine Stone Lake.

The gneisses of the southern part of the lake run in about the average direction of the length of the lake. The stream enters at the eastern end and the outlet is from a bay on the north shore about two miles to the west.

From the south-western end, there is a portage of a mile to the south, to a small lake draining to the upper part of Long-legged Lake.

Lower Medicine Stone Lake.—A short stream connects the two Medicine lakes falling into the eastern end of the lower. This is somewhat similar in character to the former, in that it is a long narrow lake, but it runs more toward the west. It is about the same length, but broadens out to nearly a mile at the western end. On the southern shore, which is low, is to be found only drift material, but the north side is bold with hills of gneiss running to the west and rising steeply. Lower Medicine Stone Lake.

At its outlet, at the eastern end, on a low point surrounded by trees, is a tall boulder of gneiss, left standing on edge by the ice. The dimensions of this stone are: height above surface fifteen feet, length fifteen feet, breadth or thickness near the top, eight feet, narrowing near the ground to five. This stone was of course an object of wonder to the Indians, and offerings of tobacco, pipes, and other valuables have been made at its base for years. This lake has evidently derived its name from this, "medicine stone." Remarkable boulder.

The elevation of the upper lake is about sixty feet above Red Lake, that of the lower one about fifty feet, and that of a long crooked lake below, near Red Lake, about fifteen feet.

The stream leaves Lower Medicine Stone Lake near the eastern end, and in half a mile reaches a small pond, on an island in which is found an exposure of light green porcellanous rock, which is similar to some in the Huronian area. The band must be narrow, as on the next small lake to the north, granite is seen, and this continues to near Red Lake. The long crooked lake lying near Red Lake is in a basin in the granite, and the fall at the outlet is across the contact with the Huronian.

In the angle formed between the two streams just described, are several small lakes which drain to the river between Keg Lake and Gull Rock Lake, but they were not examined. At the Stream at Trout Bay.

extreme west end of Red Lake, a small stream falls with heavy rapids into the long arm or bay south of Pipestone Bay, called Trout Bay. This drains a long crooked lake of clear water about seventy feet above and 700 yards south of the above arm, and like the one to the east, lies in an area of granite, the river, as in the former case, falling in rapids from the contact line. The upward extension of this stream, which flows through several small lakes, passes through an area of apparently altered Huronian which has been split off from the Red Lake band. The upper lake reached is altogether surrounded by granite.

Whitefish Spawning River.

The streams entering the northern side of Red Lake are all of small size, with the exception of one near the north-east corner. This was ascended to near its source, where there is a portage to the head-waters of the southern branch of Berens River. Atick-o-meg wam-en-e-kan Sepi (whitefish-spawn river), is the Indian name for this stream, and it is much the largest entering Red Lake. A short distance above its mouth rapids commence, and between Red Lake and Little Vermilion Lake, there are four portages in a distance of less than two miles. These are all short, and at falls, in ascending order, of eight, six, six and three feet, respectively.

Little Vermilion Lake.

Little Vermilion Lake is about four miles in length, in a north-west direction, and is divided into two parts by a narrows. The western part is much the larger, and contains many islands. Two small streams drain to this lake. The smaller enters at the north-east corner of the lower part, rising to the north-east in a large lake named Pine Lake, while the other rises in several small crooked lakes lying to the north-west, and empties into the north-west corner. Pine Lake was not seen, but the Indians describe it as a fair-sized lake, having very few rock-exposures on its shores, with a surrounding country very sandy in its nature, and clothed with scrub pine. The stream entering Little Vermilion Lake on the north-west, forms part of the through route northward to Berens River. For a couple of miles west it is wide and deep, to a small lake divided by a narrow passage in the middle, the western part containing a number of islands. Above this, the river is very crooked, and in its upper part it falls in a number of rapids at which there are short portages. Gradually the hills approach the river, sandy ridges covered with scrub pine being succeeded by hills of granite. The stream is then a series of dead water stretches, separated by short falls. The average course up to the lakes at the height-of-land is north-west, and the distance from Little Vermilion Lake to the portage at the height-of-land is about fifteen miles. The estimated fall from its source to Red Lake is 100 feet.

Route to Berens River.

The trail leading to White River, the southern branch of Berens River, is one mile in length, crossing ridges of granite and gneiss, fairly well covered by spruce and poplar. By readings of the aneroid barometer, the lakes on either side are at about the same elevation, while the ridge rises thirty or forty feet higher.

Lower par Trout Lake River.

Trout Lake River.—To the east of the high point, on the north side of Little Shallow Lake, lies the mouth of this river in a low marshy bay. To the north-east, for seven miles, the country is low, so that the river runs with wide channel in a fairly straight course. The banks are from four to eight feet, rising gradually from the lake, where they are very low. The trees near the river are mostly poplar, with slender spruce on the lower land just behind. Occasionally Banksian pine is seen on the dryer parts. The first fall met with is over an accumulation of boulders, derived from a ridge of sand and boulders through which the river has evidently cut its way. At the foot of the fall the Indians form large camps in the autumn to catch whitefish as they are ascending the river to the spawning grounds. The banks immediately above are of sand with boulders at the bottom. These are found of all sizes and colours, the largest being of dark green rock, probably transported but a short distance. The obstruction formed by these boulders, there being no rocks seen in place, causes a fall of ten feet.

Falls and rapids.

For two miles and a half above the first fall, the country seems low, and the river runs in a fairly even course from the north-east, but at this distance a heavy series of falls is encountered. Near this are exposed in the banks dark-green rocks, which at the fall are cut by light reddish granite. These are crossed by the river above, and evidently cause the fall which is estimated at sixty feet, and a portage of four hundred yards is made on the north-west side. Above this a short distance, is another series of short rapids round a long bend, amounting to a fall of ten feet. A portage of two hundred and fifty yards is made across the bend. A quarter of a mile north-west is the Manitou Fall, where the channel contracts, and the water pours over a band of fine-grained gneiss, making a perpendicular fall of fifteen feet.

The direction of the river between these last two large falls is nearly at right-angles to its general course, and in this distance it appears to cross a wide band or area of intrusive granite. Above the Manitou Fall, after a few irregular bends, it regains its former course. Cat Fall, the next above, is a narrow chute between dark-green hornblende rock of eruptive origin. The descent is about four feet, and a portage is seldom made. Above this the river broadens and the current

is sluggish. Two miles up, the stream divides, the western branch coming from Trout Lake, the eastern from Woman Lake.

Branch from Trout Lake.

The stream from Trout Lake leaves it by a bay at the south side, passing by a long narrow lake-expansion to the south-west, and turning east runs through Little Trout Lake, following a course parallel to the strike of the gneisses. The outlet from this lake is at the east end where the river follows a gradually narrowing channel ending in a heavy rapid. Below, it becomes irregular, making a course of about three miles to reach a point two miles south-east. In this distance the river falls eighty feet and four portages are made, all rather short, the longest being about 300 yards. At the lowest one, the trail runs over a ridge rising thirty feet above the river at the upper end, and by exposures on the trail the hill seemed to be principally of boulder-clay. Between this point and the junction with Woman Lake River, the course is directly south but with many minor bends and little falls through a swampy tract, in which hills of granite appear.

Branch from Woman Lake.

Woman Lake River.—The stream joining Trout Lake River from the north-east, is of about the same volume as that from Trout Lake. Just above the junction, it comes rushing through a narrow rocky gorge in the granite and gneiss, falling fifty feet, past which there is a portage-road of half a mile in length. A quarter of a mile above, a small fall of fifteen feet is passed by a portage of 160 yards, when we reach Snake Lake, the first of a series connected by short river-stretches, ending with Fly Lake, which lies east of Woman Lake near the head-waters of the stream. The second in the chain is Little Bear Lake, about thirty-five feet above Snake Lake, the ascent being distributed among six small falls, in a stretch of a mile in length. A narrow and crooked lake, six miles in length, succeeds the expansion called Little Bear Lake, and by a reach of river a mile in length is connected with the southern end of Woman Lake.

Woman Lake.

Woman Lake.—A long narrow lake expansion extends to the north-east for seven miles. Turning north, the lake widens to much larger dimensions, having an average width of a mile, for five miles of its course. This part is thickly dotted with islands, while the shores are bold, rising in high hills behind. The total length is about fourteen miles. At the northern end, a small stream leads to a couple of lakes lying to the north-east. This is the most northerly point of the Woman Lake basin, as a portage of a mile, from the upper lake brings us to the waters flowing north-east to Cat Lake River and ultimately to James Bay.

Lakes to the north.

Three lakes to the south, lying east of Woman Lake, drain directly north to this point. The first two are called Clearwater Lakes, and

the last, Fly Lake. They are long, narrow strips of water, with many islands, and are similar in character and surroundings to Woman Lake. The fall from Fly Lake, the head-waters of this branch, to Woman Lake, is estimated at forty-two feet, or from Fly Lake to the English River, at Mattawa, 451 feet.

It is found on passing through these lakes, that they occupy a trough or troughs in dark Huronian rocks. Their narrow basins closely follow the strike of the beds.

Trout Lake.—The position of this lake is to the north-east of Red and Gull Rock lakes, but a few miles from them. Its extreme length is sixteen miles and its breadth thirteen, with an average width of eight miles. Its greatest diameter lies about east-north-east or almost parallel to that of Red Lake, and nearly in the same general line. It is not, however, of the same broken and irregular character. Numerous islands are scattered through it, but in the central portion is a large open sheet of water. On the northern side are two large bays, the western one being a long narrow arm, stretching to the north-east, with a group of islands at its mouth. At the northern corner another large bay is found, almost filled with islands, and across its mouth a string of long islands extend from the eastern shore. The river leaves the lake at the south-west corner of a large bay on the south side. Eastward, another arm stretches for three or four miles, leaving a long peninsula, on the extreme end of which, in former times, the Hudson's Bay Company maintained a trading establishment. Trout Lake.

The south-western shore is regular and is determined by a long ridge of morainic material, chiefly sand and boulders, which extends in a continuous line from the western extremity of the lake south-eastward, bordering the south-western shore of Little Trout Lake, and apparently running in the same direction till it crosses the river at the lowest rapid. The height of this ridge just opposite Cat Island on Trout Lake was found by aneroid readings to be 270 feet above the lake. Morainic ridge.

Cat Island, the only large island in the lake, rises in a high dome-shaped hill about 200 feet and seems to be covered with sand. The shores, especially of the southern part of the lake, differ materially from those of all the other lakes in the district, in that they are almost everywhere piled high with boulders. The peninsula lying between Cat Island and the outlet is covered mainly with sand and gravel. The site of the Trout Lake trading establishment is at the outlet, on a high ridge of this material about thirty feet above the lake. Cat Island and vicinity.

Good soil seems to have been found there for gardens, on a small space near the foot of the slope. The place is now practically abandoned, except in the winter.

Entering streams.

The streams entering Trout Lake appear to be rather small. A little creek enters the bay at the western end, but a larger one entering at the extreme north of the lake is sometimes used by the Indians as a means of getting to Pine Lake. The river is small and only light canoes are used. At the east side, a small stream is ascended, and a long portage made, to a long lake draining eastward to Woman Lake.

Timber

The timber in the vicinity does not appear to be of importance, as the size is generally too small for commercial purposes. Banksian pine is the prevailing tree, and this generally grows in thick masses, so that the trunks are very slight. On the ridge to the south the undergrowth is of this scrub pine, and so close that it is difficult to find a way through. A few fair sized spruce trees are occasionally seen, and on the portages on the river below, wherever there is sufficient soil, a thick forest of small birch and poplar is found growing. Much of the low rocky country is covered by muskegs, with stunted spruce and tamarack.

The elevation of Trout Lake is estimated as 1295 feet above the sea, or one hundred and ninety feet above Shallow Lake, and eighty feet above the forks of the river.

Wenassaga River.

Wenassaga River.—The streams flowing south to Lac Seul are none of them as large as Trout Lake River. At the Manitoba narrows, a small stream enters from the north, called Manitou or Manitoba River. This was not explored, but is reported to be navigable for a short distance only.

At a mile from the western end of the lake a larger stream is found. This rises to the north-east, near the head-waters of a branch of Cat Lake River, and by means of a portage made from one to the other, a short route to Rat Portage is formed. The lower part and the western branch were traversed in our trip through from Trout Lake via Woman Lake and Fly Lake. The eastern branch was not explored, but a few notes on it are given by Mr. Fawcett in his report to the Surveyor General, from which the following extracts are taken.*

Description by Mr. Fawcett.

" Having heard of a canoe route from Cat Lake to Lac Seul, which could be travelled in a short time, I determined to return that way at once, and started amid a violent snow storm and before a driving

*Annual Report of the Department of the Interior, 1885, part II., p. 37.

wind, against which, had it been in our faces, we could not have made any headway. We retraced our route until Gull Lake was reached, and following a channel for about two miles, which enters the lake on the west side, we came to another large lake, also called Gull Lake, as it forms a part of the same body of water, and it is about the same size as that part of the lake crossed by the traverse line, or about five miles in diameter. The shores of that part crossed by the line are pretty regular, but the westerly shores are deeply indented with large bays and offshoots from the lake. Ascending a small creek from Gull Lake for about six miles, we reached the height-of-land portage, the first part of which was about three-quarters of a mile in length, and muskeg most of the way. We then came to a small lake which was frozen over, and were delayed for a time breaking a channel through the ice. After crossing two small lakes and three portages we reached a small stream, which, after a day's travel attained the dimensions of a fair sized river, called by the Indians Wenassaga Measibi, which we followed to Lac Seul. By this route there are altogether twenty-seven portages from Cat Lake to Mattawa varying from one chain to about a mile in length. The highest single fall would not exceed thirty feet of a direct descent, but altogether the stream from its source to Lac Seul must fall from 400 to 500 feet; and as the stream is a large one, with a plentiful supply of water, it would afford any amount of force in the form of water-power, which could be utilized should the country ever become a manufacturing one. In a few places I noticed soil of vegetable mould and clay loam, which would be well suited for the growth of grain and vegetables should the climatic conditions be favourable. I also observed here that the best soil generally produced a growth of poplar, and wherever it appeared large and thrifty, good soil might be looked for, comparatively free from rock. On the rocky ridges, as usual, scrubby pine was the prevailing timber, while the flats and muskegs were invariably covered with spruce and tamarack. The good land noticed seemed to be in belts three or four miles wide and extending north and south for a considerable distance, as might be expected from the geological formation, the depressions and elevations succeed each other in very regular order and much in the same direction. In places the spruce and tamarack would attain a growth of two feet in diameter and a good height, but this was not the rule—ten or twelve inches was about the average."

Soil and timber.

In its lower part this stream passes through two moderate sized lakes. The first, Wen-áste-ga-o Lake is situated at a couple of miles from Lac Seul at an elevation of sixteen feet above it. This fall in the river occasions three rapids, the first of which has a fall of six feet

Lakes on lower part of river.

and is a mile from the mouth. A small rapid just above, is next tracked up, above which to near the outlet of the lake the river is deep and easily navigated. Just at the outlet, a band of micaceous gneiss forms a barrier and the river falls three or four feet. A short portage on the west bank leads to the lake which is three miles long and one broad. On the west side runs a high ridge of hills, of granite and gneiss. On the east the hills are lower, and the exposures of rock form flat glaciated surfaces, while in one locality the waters of the lake have worn into a bank of sand, laying bare fifteen feet of stratified beds. For some little distance up this river and past the next lake, a small stratified deposit of sand fills the narrow valleys and depressions between rocky knolls. In the river above, the course of the stream is between ridges of gneiss running south-west. The river breaks through from one ridge to another, but the older valleys between these ridges appear to be filled in with the sand deposit.

Bluffy Lake

The two lakes through which the river runs, are of much the same character, except that the upper one, Bluffy Lake (Kah-mini-ta-gwa-qui-ack Sakahegan), is dotted with several islands, and one, a mile in length, divides it into two portions. The difference in level between these lakes is about sixty feet, which is found at two heavy falls near the outlet of the upper one. The first or lower rapid has a fall of nearly forty feet, then, at the outlet, is another of twenty feet over a ledge of mica schist. On the portage at the lower fall the rocks are very much twisted and broken into by dykes of reddish granites. At the upper one, less disturbance was noticed, while on the lake the beds are not contorted but show considerable squeezing.

White-mud River.

The total length of Bluffy Lake is four miles and a half, with a width of one mile. The timber on the islands and surrounding hills is principally black spruce, with Banksian pine showing occasionally on sandy tracts in the river-valleys. At the upper end of the lake a stream from the east enters by a wide mouth. The volume of water coming in is not great, as the channel soon contracts to a small stream with muddy water evidently draining from a valley with soft clayey deposits. This stream was not explored, but with small light canoes it might be ascended for some distance It is called White-mud River (Wab-an-unkie-Sepi).

Main river above Bluffy Lake.

The main stream for two or three miles above, flows in a wide channel through a low country, with the borders of the stream rush-covered, and in many places wild rice is found growing thickly. A band of mica-schist crosses a bend in the river, causing falls of three or four feet at two places, between which is a small lake or pond. To the east,

and connected by a narrow opening, lies a lake of over a mile in length, at the eastern end of which the Sand-bar River enters. This is said to drain several lakes lying further to the east.

To the south are some sharp hills that have the appearance of being of the same nature as the ridge of gravel and sand, seen at the north end of Shallow Lake.

From the pond above mentioned to the forks, a distance of five miles, there are four small falls, one with a fall of three feet; two about half way, aggregating five feet; and one of four feet, half a mile below the forks.

Western branch.

The general direction from Lac Seul is north-east, but the main branch from near Cat Lake River seems to be coming more directly from the east, while the smaller branch is from the west-north-west, the two branches meeting in the same valley and the united stream leaving at right-angles to the branches. The western stream flows in a deep channel, bordered by a tall forest of poplar and birch. At two miles west, a small lake is entered which has been gradually filling with silt and sand brought down by the stream from above. The inlet is on the western side, where a delta has been formed, stretching nearly across the lake. This is at present only a low grass and rush-covered flat, but shows clearly the effect of a settling basin for a small stream carrying fine sediment.

A series of falls or rapids amounting to twenty feet, just above the lake, is avoided by making a portage from the extreme northern end, 1300 yards, to the river above. The upper part of the stream becomes very crooked, winding back and forth in the bottom of a valley between ridges of dark green schists running west of south. The immediate banks are low and generally composed of fine silt, the slope back being gradual, through swampy moss-covered ground to a terrace of sandy material. Occasionally the stream cuts into the sides of the valley and shows stratified sands and silt.

Fly Lake.

The portage to Fly Lake, leaves this stream at a bend just below a heavy rapid where the river turns more to the east. An estimate by barometer readings, gives the elevation of Fly Lake as fifty feet above the stream at the foot of the portage, and the distance by pacing is half a mile.

Berens River Basin.

Survey by Mr. Low.

The lower part of this stream was explored and surveyed by Mr. A. P. Low, of this Department, during the summer of 1886, while pas-

sing through to Hudson Bay via the Severn River.* His route to the head-waters of the Severn, led by Berens River to Fishing Lake, just above the Grand Rapids of Berens River. Thence he turned up a small branch coming from the northward, and by a number of portages reached the Severn River. Mention is made in his report of a large branch called the Mattawa, which rises near Cat Lake, falling in at the south side of Fishing Lake. From the fact that this branch apparently occupies the central position and is longer than any of the streams flowing in the basin drained by Berens River, it would seem that it should be considered the main part of the river. The lower portion is described as being a succession of chutes or short falls, with quiet water-stretches resembling the locks and reaches of a canal.

Lakes on Berens River.

The larger lakes found on the course of the river to the eastern head-waters are, in ascending order, as follows: Family Lake, on which the main Hudson's Bay Company's trading post for the inland district is established; Fishing Lake, just above, the waters of which fall to Family Lake by a heavy rapid called Grand Rapids, giving the name to the Hudson's Bay post. Above this, on the Mattawa branch, the first large lake is Eagle Lake. This is followed by Rocky Island Lake, Sandy Narrows Lake, on which a Hudson's Bay post was at one time established, and Moose Lake. These are generally connected by short river stretches, forming a chain lying in an average east-and-west direction. A long reach of river from the south, in which there are several rapids, drains Pekan-gi-kum (dirty water narrows) Lake. Above this are Goose Lake, Fairy Lake and Upper Goose Lake.

Survey by Mr. Cochrane.

The detailed description of part of the river above Family Lake, to Moose Lake is taken from unpublished information, the notes of the late Mr. A. S. Cochrane, who explored it in 1882. A rough sketch of the part above Moose Lake to Pekan-gi-kum was made by A. W. Ponton, D.L.S., in 1888, while *en route* to the latter lake to locate and survey an Indian reserve.

Family Lake to Eagle Lake.

The canoe route from Family Lake eastward to Eagle Lake, leaves the main river and follows a string of small lakes in a more direct line, avoiding the long portage at the Grand Rapids, and also the difficult navigation of the short stretch of river between Eagle Lake and Fishing Lake. By following an eastward extension of Family Lake and ascending a small stream, with three short portages, a long, narrow lake is reached, which connects by a swampy channel with Eagle Lake. The estimated difference in height between these two large

*Annual Report, Geol. Sur. Can., vol. II. (N.S.), 1886, part F.

lakes, Eagle Lake and Family Lake, is about fifty feet, and in time of high water it is reported that an overflow from Eagle Lake takes place down this valley. Eagle Lake is very irregular in the outline sketched by Mr. Cochrane. The northern part, near the outlet, is full of islands, while the many channels around islands, render it difficult to mark the eastern end.

The first rapid above, is on one, of a possible two channels, and has a fall of three feet. Further up, the river expands into another lake, likewise full of islands. Mr. Ponton calls this Rocky Islands Lake (Ka-sah-pah-wa-ka-muck Sakahegan). Isolated knolls situated near the shores are estimated to attain heights, of one hundred and twenty-five and one hundred and fifty feet above the lake. This lake gradually contracts to river dimensions to the east, and a series of rapids occur at which four portages are made, rising twenty-six feet to another expansion, which forms perhaps the largest or longest ake of the series—Sandy Narrows Lake. This, like Rocky Island Lake, is of very irregular shape. The route followed, was mainly near the north shore, which maintains a fairly continuous line to the east-north-east. Bays running to the south-east, or large expansions partly inclosed by islands, are indicated on the sketch. On a point near the Sandy Narrows was some time ago located a trading post of the Hudson's Bay Company. This may have been the "Albany House" marked on previous maps near this latitude. The extreme length given by Mr. Cochrane for this lake is thirty miles, in an east-north-east direction. The shores are flanked by hills averaging one hundred and fifty feet high. Eagle Lake to Sandy Narrows Lake.

The river enters at the north-east corner and comes from Moose Lake, eight miles above, by the course of the river. In this distance the falls aggregate forty feet, with portages at four points. The northern branch above this, Crooked-mouth River, forms a route to Trout and Deer Lakes, to the north, and enters Moose Lake at the north-west corner. The portage at the head of this branch, over the height-of-land, is in direct distance five miles north of Moose Lake. Crooked-mouth River

The main stream appears to enter at the south and comes from Pekangikum Lake, at a distance of thirty miles. In this distance the river widens out in several narrow lake-like expansions, dotted with islands. Nearing Moose Lake, it makes a long detour to the westward and back again, finally falling into a narrow arm at the south end, at the Eye Rapids. There are four other rapids and portages on this stretch of river. The portages are mostly under a quarter of a mile, except one which is three-quarters of a mile long. Berens River

Mr. Cochrane's notes.

Mr. Cochrane passed down by the northern branch through Moose Lake, Sandy Lake and Eagle Lake to the Grand Rapids. A few extracts from his notes serve to show the appearance of the country, on this route, at that time.

Height of land.

"The height-of-land portage (from the basin of Severn River) crosses a very low hill (about forty feet), at the south end, but it is for the greater distance over low marsh ground with some muskeg; and until Moose Lake was reached the Crooked-mouth River continued to pass through low swampy ground. The only change in the country noted to Sandy Narrows Lake is in its timber, which is mostly better, owing, no doubt, to some good soil being near the river. Indeed, in two or three places good clayey soil was seen, but only in small patches.

Moose Lake.

"The shores of Moose Lake have all been burned over long ago, and are now characterized by brulé and second-growth. On other parts of this river to Sandy Lake some good tamarack has been seen, occasionally twelve to fourteen inches in diameter. Spruce is about the same size, while Banksian pine is not larger than ten inches.

Sandy and Rocky Island Lakes.

"Sandy Lake, through which we passed (and at the foot of which I obtained a very satisfactory observation for latitude, 52° 04′ 54″) is generally speaking surrounded by rocky hills averaging 100 feet, now fairly covered with the usual second-growth, amongst which is a good deal of green timber. The shores of this lake, as also those of the next below (Rocky Island Lake) are mostly rocky, though an occasional short sandy tract is to be seen between the rocky points. About three-quarters of the way down the lake, is what is called the Sandy Narrows, at which the lake becomes constricted and is bordered on both sides by low sandy banks. The bottom, except for a narrow channel at one side, is also sand, and the water too shallow for canoes.

"The river connecting these lakes is a tolerably large one. The portages are made mostly at falls and chutes with steep tracks. They are, however, all short ones and in good order. Soil of good quality was seen at only one point, viz., the second portage below Sandy Lake, where it is a stiff grayish-clay with a slight covering of dark sand. It does not, however, appear to extend beyond the point across which the portage has been made."

Notes on rocks.

The notes relative to the rocks of this part of the river and lakes traversed, are given below:—

Moose Lake, south side: Coarse, dark-gray, massive granite; glacial striæ, S. 85° W.

Eastern end of Sandy Lake: Dark-gray and grayish-brown gneiss; dip, N. < 30°; striæ, S. 75° W.

Two miles from east end of above lake: Dark-gray gneiss containing large quantities of hornblende and some iron; highly polished surface.

Sandy Lake two miles east of Sandy Narrows: Very coarse dark and light brownish-gray gneiss, containing a few small transparent amber-coloured grains of quartz and much hornblende; dip, N.E. at a high angle; striæ, S. 75° W.

Western side of Eagle Lake: Coarse dark and light gray micaceous gneiss; dip, N. < 20°.

Eastern end Family Lake: Dark gray gneiss; dip, E. 25° N.

Dark gray gneiss seems to be the prevailing rock of all this region.

The land reserved for the Indians on the upper part of this branch of Berens River, is a small tract situated on the north side of a long arm or narrows, running to the eastward, from a lake to which the name Pekangikum is given. The river enters at the eastern end of this area, coming from Sturgeon Lake by a short stretch of river half a mile in length, in which there are two rapids. The Indian reserve appears fairly well timbered—principally with Banksian pine of slender growth and some spruce. The Indians have been able, in building their houses to obtain timber of suitable size for the walls and rafters, and spruce of a diameter of fourteen inches is fairly plentiful. The shores of the lake are rocky, but strips of country inland appear, on which there is probably a fair quality of soil, though the surface is generally sandy. On one of the islands in the larger part of the lake, soil of good quality (clay) was seen, on which the Indians were growing potatoes. No doubt there is better land for this purpose on the reserve they have selected, but as they make their summer camp on a small island near the deeper part of the lake for the purpose of fishing—by which they mainly subsist—they naturally utilize the nearest land for their summer gardens. Indian reserve.

The Dirty-water Narrows, which runs eastward from the reserve, is about eight miles in length, and averages very little over a quarter of a mile in width. The shores are mostly rocky, but not very high and generally moss-covered, with a thick growth of small spruce and Banksian pine. At the end of the bay or arm, an abrupt turn south is made to the first rapid above the lake. This is in a narrow gorge, but at ordinary water there is very little fall (three feet, 8th July, 1893), and the portage is ten yards across a low rocky barrier, stretching into the channel. In high water, this rock would be

covered and the river must fill the whole width of the gorge. Half a mile south of this, at the south-east corner of a small basin, there is a fall of eleven feet over a wide ledge at the western end of Sturgeon Lake. The high-water mark in the basin between the falls, was six feet above the actual level, an effect due to the contracted channel at the lower fall, compared with the wider one of the upper.

Sturgeon Lake.

The lake above this is a long narrow one, with a great number of islands scattered along its length, which is nearly seven miles. The width does not average over a mile. The direction of the length of the lake, is, for the first half east by south, then north-east. The shores are mostly high rocky hills, in many places burnt over, and the timber is small. Near the north-eastern end, the shores along the southern side become low and better wooded. The river enters on the west side, one mile from the extreme end of the lake, flowing through low land, evidently a delta deposit. It is now well timbered with spruce, poplar and birch, of fair size.

Berens River above Sturgeon Lake.

The river makes three long bends before any swift current is encountered, and at about seven miles the first rapid is met. This is situated about three miles in a direct line north-east from the lake, and is called Mick-kai-ame Pow-estick. There is here a fall of thirty feet over gneiss, very much broken by veins and dykes of red granite. The portage is on the north side, 350 yards in length, over a steep hill of sand and boulders. This appears to be a ridge of drift material which crosses the river at this point, and, by Indian report, continues to the southward to the Trout Lake ridge.

Above this the river turns more to the east, and several small rapids occur, up which the canoes are handed, till at three miles the stream divides, the northern branch, Throat River, being the one followed on the route to Cat Lake, the southern, the route toward Woman Lake. These two branches are of much the same size. Half a mile up the southern branch is the Otter Fall, of fifteen feet, where there is a portage of two hundred and thirty yards. Above this the river, to the next fall, comes from the south; the banks are mostly low and rocky and the timber is a mixture of spruce, tamarack, poplar and birch. After following a crooked course of two miles of this nature, there is another fall of eight feet, Pin-un-ge Pow-estick, or Child Falls, with a portage of seventy yards on the south side, through small spruce.

Timber.

From this fall to the mouth of Windfall Creek, eight miles in direct distance to the east, the river gradually rises by small rapids, there being three portages, the first at two miles across a sharp bend

through woods of Banksian pine to avoid a rough rapid with fall of five feet, the second at a long rapid, and the third a short distance above, where an island on which is the portage, divides the channel. The banks are mostly low and swampy to past Windfall Creek, and with sluggish current to Hair Lake. Tamarack and spruce are the principal trees, small in size, growing in low, swampy ground. Occasionally a small knoll is seen, with poplar and willow scrub. The channel from the mouth of Windfall Creek to Hair Lake is nearly straight, running about east and west, the distance being about eight miles.

Owl Creek, a small stream, enters a mile below Hair Lake, coming from the south-east. Hair Lake is about one mile and a half in length, lying north-and-south. The river enters at the south-east corner and leaves by the south-west. The distance across the southern end is about a mile, and the shore, there low, slopes gradually to the lake, of which the bed appears to be shallow, as most of the southern part of the lake through which we passed, is dotted here and there with slender rushes, possibly suggesting the name to the natives. In the northern portion there is deeper water, and whitefish are said to have been caught there. Hair Lake.

A distance of only a mile separates this from Goose Lake, and at half the distance, is the White Dog Fall, a descent of eighteen feet.

Above Sturgeon Lake, on this branch, there are but three lakes of any size, namely, Goose Lake, Fairy Lake, and Upper Goose Lake. These are all situated near together, separated by short river-stretches. The first is four miles in length, by one mile wide, lying east-south-east and west-north-west. The river enters at the east end and leaves at the west. The Hudson's Bay Company had an outpost established at the eastern end in former years, but it is long since abandoned. A short length of river connects with Fairy Lake to the south-east. At a mile up this is Woman Fall, the highest on this part of the river. Here there is a drop of forty-five feet, in a narrow gorge, over ledges of gneiss forming a series of steps. The portage is on the north side, of one hundred and twenty yards, through poplar and spruce woods. A little further on, another fall occurs, of twenty feet, with a portage of two hundred yards. This ends at a small lake, from which a wide channel to the south connects with the north end of Fairy Lake, which is thus at least sixty-five feet above Goose Lake. We entered at the north, and travelled a mile and a half along the eastern shore to the mouth of the incoming river. The main body of the lake stretches away to the south, as a narrow area of less than a mile in width and perhaps five miles total length. The south-eastern shores Goose Lake. Fairy Lake.

Upper Goose Lake.

are low, the higher land bordering the western side. The third lake of this series is called Upper Goose Lake or, more literally, "the lake where they kill geese," and is three miles east of Fairy Lake. The river connecting them is broad, deep and sluggish. The lake is less than five miles long and is slightly wider than the last. The longer diameter lies east-and-west, the river entering at the western extremity.

Head-waters of Berens River.

Above this are two small lakes through which the river passes, and between them is a fall of four feet at the "Eagle Rapid." A mile above the upper one, the river divides, the eastern branch being the Whitefish River while the southern one is the main stream. This then turns south and passes through a low swampy tract for three miles, when, nearing some rugged hills, it becomes less sluggish and small rapids are met with. The main part of the stream then turns to the west, coming from a series of lakes in the hilly region. A small branch falls by a series of shallow rapids to this stream, which branch was followed in order to reach the height-of-land to the east, making two portages of one hundred and eighty yards each, rising ten feet to a swampy tract in which the stream is deep and sluggish but very crooked. Portages are made at several shallow rapids, to the height-of-land. The direction of this latter part is to the south-south-east and a distance of twelve miles, the estimated fall in which is over eighty-five feet.

Height-of-land portage.

White River.

Southern Branch of Berens River or White River.—The largest of the tributaries of Berens River, coming from the south, is the White River which enters at Pekangikum, at the extreme outhern end of the lake. This stream comes from a point directly south at a distance of twenty-five miles, and passes through two or three crooked lakes, falling in that distance over two hundred feet. This estimated fall is merely the sum of the falls on the river with an estimate for current. The greatest is that at the first long portage where it is sixty feet, the rest being made up of a number of smaller rapids and chutes. There are twelve portages to reach the height-of-land, mostly short. The last is the longest, being over a mile in length. In following this small stream upwards, it gradually contracts in size, until near the head-waters it is so small that the whole distance between the last two lakes has to be portaged. This portage, over a mile in length, starts in a tamarack and spruce muskeg, moss-covered, but eventually reaches higher ground with mixed timber, mainly hills of sandy, boulder-strewn material. The prevailing tree is Banksian pine, and towards the eastern end of the trail this has been thinned out by fires and wind storms, leaving a grove (at the far end) averaging ten to twelve inches in diameter.

Just below the lake-stretches, near the height-of-land, the river cuts through sand hills, forming a deep valley, and at one of the portages clay was noticed resting directly on the rock, the sand evidently lying above it.

Lakes of Berens River basin.

Estimated Heights of Lakes.—A series of estimations of the falls and rapids in the river was carried through from Lac Seul to Pekan-gi-kum, on Berens River via White River, and thence up the eastern branch to the head-waters of Cat Lake River, and south by Trout Lake River to Lac Seul.

The results are given for those lakes in the area drained by Berens River, and are the estimated heights above sea-level in feet, assuming Lac Seul as being 1140 feet.

	Feet.
Lake at height-of-land, White River	1250
Lake at latitude 51° 25′, on White River	1225
Lake at latitude 51° 33′ "	1175
Below Long Portage, latitude 51° 37′, White River	1100
White Lake, White River	1040
Pekan-gi-kum Lake, Berens River	1037
Sturgeon Lake, "	1051
Hair Lake, "	1178
Goose Lake, "	1196
Fairy Lake, "	1261
Upper Goose Lake, "	1262
Lake at height-of-land to Cat Lake River	1350

Geological Features.

Archæan rocks only found.

In the country under consideration, the rocks exposed are all Archæan, consisting of gneisses and associated granites, classed generally as Laurentian, and folded schists and greenstones of the Huronian. In many respects these rocks are counterparts of those found in the districts further south on the Lake of the Woods and Rainy Lake. The northern boundary of the large Huronian (Keewatin) areas already explored there, is roughly on a line from Rat Portage to the foot of Minnietakie Lake. North of this a band of gneisses occupying the shores of Lac Seul and the English River, is succeeded by a similar series to that on the south. The irregular form assumed by these Huronian areas in both districts, is no doubt the result of simultaneous crustal movements. The Laurentian gneisses are the prevailing rocks of the whole region, and their association here with the folded schists, greenstones and rocks of apparent sedimentary origin, is of special interest in view of the auriferous nature of many

of the quartz-veins found cutting similar rocks in the vicinity of Rainy Lake and Lake of the Woods.

Previous geological observations.

Former Explorations.—A part of the area has been briefly referred to in former reports of this Survey :—

Notes by Dr. Selwyn.

Dr. Selwyn,* in 1872, in describing a journey from Lake Superior to Lake Winnipeg, passing by English River through Lac Seul, calls attention more particularly to the soil and drift deposits, and instances the sands and clays in the valley of the English River as being of greater extent, than further south and west on the Winnipeg River, except perhaps on the lower part near Lake Winnipeg. In speaking in a general way of this district he says† :—" There are no prominent hills or even ridges ; the highest elevations do not probably exceed four or five hundred feet above the intervening waters ; and I think it is no exaggeration to say that the latter occupy fully one half of the whole surface area of the region. The surface is gently broken and undulating, and often rocky, but occasionally both lakes and rivers, are bordered either by extensive swampy flats or by banks of stratified sand, silt and clay, which often rise terrace-like at a short distance from the water's edge. The point on which the Lonely Lake Post stands is formed of these deposits, and to the westward of the post, along the north shore, they are exposed in cliff sections for several miles. At the junction of the Mattawa [Shallow Lake River] and English Rivers, where a small Indian village and trading post is situated, presided over by Chief Pierre, there are similar banks of sand and sandy clay, resting on the ordinary gray Laurentian gneiss, which is exposed along the water's edge. The banks here rise steeply to about thirty feet above the water, and for some distance inland the country seems to be tolerably level, and the soil on this part of the river appears to be generally of fair quality."

By Dr. Bell.

Dr. Bell,‡ who accompanied Dr. Selwyn on this expedition, reports more fully on the rocks met with. Of those seen on Lac Seul or Lonely Lake he says § :—

" The rocks observed around the shores of the western section of this lake consist entirely of Laurentian gneiss, all having a west-southwesterly strike. We noted many varieties among these rocks, but none of them are remarkable or require special description. * * * About the outlet the gneiss is very micaceous, and is cut by numerous granite veins, mostly running with the strike which is here nearly due west. The granite, as in many other places, may here indicate the

*Report of Progress Geol. Surv. Can., for 1872-73, pp. 8-18. †Ibid., p. 16.
‡Ibid., 1872-73, pp. 87-111. §Ibid., p. 103.

proximity of a band of Huronian schists. The Indians at the mouth of the Mattawa [or Shallow Lake] River showed us specimens of a soft, gray, uncrystalline slate, which they carve into pipes, and informed us that they obtained it from the solid rock at Oninini Sagaigan or Red Paint Lake, which, from their description, would appear to lie about five miles north of the junction of the two rivers. These facts appear to show the existence of another band of Huronian rocks, which, judging from the strike, would be identical with the one observed before the junction of the English with the Mattawa River."

In 1883 Dr. Bell again visited this region and made a survey of the Mattawa and Red Lake Rivers to Red Lake. In the Summary Report for that year, he gives a short account of his route to Red Lake. The notes bearing on the geology of this area are contained in the following paragraph.*

"A very careful track-survey was next made of Red Lake itself, as its shores proved to be of great geological interest. The whole lake (which is of considerable size) lies within a wide belt of Huronian rocks, among which several of the rarer varieties are well developed, and they were found to contain some interesting minerals. The narrow belt of Huronian rocks, which, in 1872, we conjectured would pass a few miles to the northward of the junction of the English and Mattawa rivers, was actually found in the position and strike it was then supposed to have."

The Laurentian.

Laurentian Gneisses.

Gneisses referred to the Laurentian were seen on the White and Berens rivers, on Lac Seul and on the English and Mattawa rivers. At the head-waters of Berens River, large masses of unfoliated granite seem to break into the gneisses and in other parts similar granite cuts the darker rocks of the Huronian. In the Lac Seul area the strike is very uniform, generally trending to the west, but this extends northward only a few miles from English River. On the river from Long-legged Lake the western trend is maintained to near the outlet, and on Shallow Lake, to a point about one-third the distance up the lake. Up the Wenassaga River this uniformity of strike does not seem to continue far from Lac Seul, as on the portage below Bluffy Lake the rocks become very much crumpled up. This crumpling is seen in the rocks on the east side of Shallow

*Report of Progress, Geol. Surv. Can., 1882-83-84, p. 5.

Lake and shows a line of weakness running from south of Bluffy Lake to Shallow Lake and thence to the outlet of Long-legged Lake.

Rocks of Lac Seul.

Rocks of Lac Seul or Lonely Lake.—The beds from the outlet eastward are generally gneisses and mica-schists, with interbedded light-coloured granites all trending about east and west. Near Big Island they run west-south-west and east-north-east, and at the narrows at the western end of the island, many red granite veins break into the beds, altering them to a slightly lighter gray. On the south side of the island is a long exposure of a reddish granite which breaks easily, like a sandstone. This is, however, found to be cut by the red veins of granite which also cut the gneiss. At the Shanty Narrows, the rock is a light granite or slightly foliated gneiss interbedded with garnetiferous mica-schists, and the strike bends from west-south-west to south-west, but quickly turns again to an east-and-west direction. At the Manitou Narrows the rock is a whitish granite, with a few streaks of dark foliated rock made up of fragments flattened out and somewhat rounded at the ends. Near the long point west of Stony Point, a small island is found to be composed of light-coloured crystalline granite, with slight signs of foliation.

Brecciated contact.

Three miles east of Stony Point, a small island, connected by a gravel bar to the mainland, is composed of dark-green bedded rocks. They are standing on edge, striking about east-north-east and are found on several of the islands lying on that line. The main shore to the north is of granite, very like that on Big Island, and it here contains many fragments of the green rocks, forming a brecciated contact. A wide dyke of graphitic granite cuts through the beds on the point, but whether it connects with the granite of the mainland or cuts it as well, was not ascertained.

English River below the lake.

On English River, the beds at the outlet are very much wrinkled, and at the first rapid, bands of dark mica-schist and dark-gray gneiss, interleaved with coarse whitish granite, are seen. Below the second rapid, on the point opposite the portage, the beds are very much broken and twisted, so that pieces of the darker bands are broken off and carried forward in the mass. A coarse gray granite showing some foliation, occurs at Mattawa, and is followed two or three miles up the Mattawa River by dark hornblende-schists with a general east-and-west strike. At the elbow, about half way to Shallow Lake, red granite dykes are seen cutting the schists. The south-western arm of Shallow Lake is principally surrounded by hills of gneiss and granite of the Lac Seul type, ending at a point three miles and a half north of the outlet, where the gray gneiss is found to contain rounded masses of

Mattawa to Shallow Lake.

darker inclusions. Across the lake, half a mile north, dark fine grained mica-schists, very much crumpled, are cut by salmon-coloured granite. These may possibly be altered beds belonging to the same series as the rocks of the north-western part of the lake, and this point would then be about the northern limit of the Lac Seul Laurentian band.

English River below Mattawa.

Below Mattawa, the river widens to a small lake that discharges in a series of rapids, along the banks of which light granite-gneiss, running west-south-west is found, and occupies the sides of the stream to the next fall, the river running in a trough parallel to the strike. Bands of mica-schist become frequent, and on breaking through these to the south the river falls into Barnston Lake. Gneisses which call for no special remark are seen on the banks of the lakes, forming expansions on this part of English River.

Long-legged River.

The stream from Long-legged Lake which falls into Wilcox Lake was explored and mapped. The rocks are mostly a repetition of those on the English River and maintain a nearly uniform strike to the westward, varying locally, the altitude being generally vertical, but occasionally a dip of 45° south was found as the extreme variation. Fewer exposures are seen on these small rivers, owing to the current not being able to wear away the surface covering.

Wenassaga River.

The northward continuation of the Laurentian of Lac Seul on the Wenassaga River, is found to show some changes in character. On Lac Seul, a series of granites is found interbedded with mica-schists. On the upper part of Wenastegao Lake, and on the river above to near Bluffy Lake, little change except that of the strike was noticed; but at the long portage, as noted before, the beds are very much crumpled and folded, over a short distance, and on Bluffy Lake return to a uniform south-west and north-east strike. Following these beds north-eastward, they are found to curve slightly more to the east, and at the east end of the lake are running about west-south-west and east-north-east. The gneisses are generally reddish to gray, and specimens taken from a small island near the eastern end, show layers composed of nearly pure quartz. On a smooth surface, this rock is seen to be made up of a series of lenticular grains which are the result of subsequent squeezing and perhaps shearing, while in a plastic condition. The gneisses seem to have the same structure.

Bluffy Lake.

Wenassaga River above Bluffy Lake.

At the entrance to the river above this lake, is an exposure of dark gray felspar-mica gneiss. The grains of felspar are very even in size, of a light colour and surrounded by flakes of black mica. Streaks of granular quartz run parallel to the foliation. The next exposures are near the outlet of Sand-bar Lake, where a ridge of dark gray gneissic

schist crosses the valley. Along the north shore the rocks are mostly a dark mica-schist, cut through by dykes of a light, very coarsely crystalline granite. On the river above, the schists form another dam and fall, where light gray gneiss is followed by a wide band of fine-grained schistose gneiss. The rocks exposed on the river above are probably of Huronian age, but the contact between the two series must be concealed by the surface covering, as the river for a short distance runs through a low swampy flat where no rock is seen.

Rocks of Lac Seul and Long-legged Lakes compared.

Rocks of Long-legged Lake.—Just at the entrance to the lowest lake of the series, a band of dark fine-grained hornblende-schist is found at the rapid. The strike of the gneisses about a mile below this is almost directly west, but half way between, a dark fine-grained gneiss strikes to the west-south-west, and at the upper rapid, where the fine-grained hornblende-schists are seen, the strike has turned to the south-west, which direction of strike is maintained to the west end of these lakes. It is thus shown by the line of weakness traced to the eastward, by crumpling and a change of strike, that a distinction is here to be drawn between the Lac Seul type of Laurentian, as found in the river, and the gneisses of the Long-legged lakes, which all trend to the south-west, or nearly at an angle of 45° to the former rocks.

Details on Long-legged Lakes.

On the lower lake are chiefly granites and gneisses. On the south-east shore are gneisses with a light porphyritic granite, and at the south end of the bay, the granite is found to hold dark oval patches or inclusions, while on the point south of the opening to the second lake, are masses of dark hornblende-schist which look like outlying fragments of Huronian, included in the foliated granite. These rocks are immediately followed to the west by dark gneiss. Passing through a narrows, the second lake is entered, and here the rocks are generally gray and red granite-gneiss; the exception being a small island of light-green fine-grained rock resembling that of the Huronian, but its relation to the surrounding gneiss could not be seen. On the west shore, a band of dark schist touches the shore and occupies a long island, but is followed by light-coloured gneiss, and this again by reddish gneiss and granite. On the narrows just at the entrance to the last lake, a band of dark-green coarsely crystalline rock was found, similar to some of those seen on the Red Lake River, and there supposed to be an eruptive associated with the Huronian series. Near the west end of this bay, another band of dark rocks was seen, the intervening beds being generally light-coloured gneisses.

Dark bands.

This recurrence of the dark bands at intervals of two or three miles suggests the possibility of their being the lower edges of a series of

folds of the Huronian. They seem to be accompanied in nearly every case by a few broken patches of dark inclusions in the adjacent beds, and in the case of the first one, on the west side of the lower lake, the continuation of the band on the south shore was indicated merely by such fragments in the gneissic rock.

On the hills to the south-west the beds are horizontal, but soon take a dip to the south-east; a mile east the dip is south-east $< 20°$, at the second lake it is south-east $< 30°$ to $45°$, and at the outlet the beds are almost vertical. Dips.

The absence of anything in the nature of mica-schist is a character of the gneisses of Long-legged Lake and also of those to the north-east on Bug Lake and Gull Lake, and the grouping of these rocks together, as being of common origin, is suggested from their being nearly on the same line of strike and separated by a very short interval in distance.

To the north-east of this group of lakes, on Gull Lake and the small lake lying to the east, is found an area in which light, slightly foliated granite is the prevailing rock. This, at its contact with the Huronian of the west shore, has sent long, finger-like masses between the beds, separating them. Fragments are found in the granite at some distance from the contact, and a band lying to the south of the Huronian, seems to be made up entirely of these fragments cemented together by the granite. At a greater distance to the south, these fragmentary rocks gradually assume the aspect of altered beds cut into by the granite in veins and dykes. Contact with Huronian.

On the Upper Medicine Stone Lake, a mass of granite forming a triangle between the two lakes, deflects these altered beds to the south-west, and it is possible that the gneisses of the lakes to the south of this may be a continuation of highly altered beds similar to those above, but in which the gneisses and foliated granites are also cut by a red granite. The larger dykes of granite cutting these gneisses at the western end of Long-legged Lake are of a light red, and suggest a possible connection with the large granite mass of the west shore of Medicine Stone Lake, while the granites and foliated granites found cutting, and interbedded with, the gneisses and dark-green schists of the middle and eastern lakes, are probably connected with the granite area east of Gull Lake. Upper Medicine Stone Lake.

Rocks of Trout Lake.—The Trout Lake area is probably all Laurentian, but the existence of Huronian in the immediate vicinity is to be conjectured from dark metamorphosed rocks in fragments and small masses held in the gneisses at several localities. Laurentian of Trout Lake.

At the outlet of Little Trout Lake, a small band of dark rocks very much seamed by red granite veins, is accompanied by granites and gneisses. This, by reference to the map, will be found to be a probable continuation of the south-west extreme of the Woman Lake beds. The south shore, on the continuation of this strike was not visited, but it is quite probable that traces of this band might be found connecting this area with the Red Lake series.

Another locality presenting somewhat similar features, is at the western extreme of Trout Lake, where the gneiss contains spotted bands looking like conglomerate pebbles of dark rock with a matrix of lighter colour.

Strike of gneisses on Trout Lake.

On the narrow water connecting Little Trout Lake with the larger one, are beds of a gray gneiss, the foliation running about south-west. The same strike was found to be common to the gneisses of the south-eastern part of the lake. Few exposures are seen on the south-west side and they are of an unfoliated granite, but on the extreme western end they become more gneissic, running about west.

On one of the points at the entrance to the western bay occurs the spotted band mentioned above. The whole point is foliated in a direction about north-west and south-east, the plane of foliation dipping south-west $< 60^{\circ}$. Half a mile north-west the point is a mass of reddish gneiss, the foliation is distinct but the mass is lighter coloured than the last and is nearer to a granite. Across the bay to the north, on the extreme north-western shore, the rock is a dark gray gneiss with foliation running to the north-east, cut by many seams of red granite. Eastward on the north shore, the gneisses are light gray and red, and of much the same character, preserving a general north-east and south-west strike.

Laurentian of Whitefish Spawning River

North of Red Lake, the Laurentian rocks are found to touch the northern shore of Pipestone Bay, and the hills north of a long arm on the north side look like granite, while on the lake, veins of granite cut the schists. The contact is evidently near at hand, and a short distance up the Whitefish Spawning River is an exposure of somewhat greenish granite, which seems to include small masses and crystals of a dark green hornblende or pyroxene giving it a darkened colouring.

Farther north, the granites are lighter in colour and show slight foliation. On the small lake above Little Vermilion Lake, the rock is a light-red fine-grained granite, and little variation, except in respect to traces of foliation, is observed on the upper waters of this stream. Red granite is observed on the height-of-land portage, and on the lakes forming the head-waters of the streams flowing north and south.

The granite at the head of Pipestone Bay, near the contact, shows some traces of green coloration from the Huronian rocks, more especially along cleavage planes. The foliation is slight and the colour is reddish, mottled with gray, fine, granular material which increases near the contact. The broken inclusions of Huronian schists, so common at other contacts, were not noticed along the north side.

Laurentian of Berens River.

Rocks of Berens River.—The geological character of the country lying north of the height-of-land to Berens River, is given altogether by exposures of gneisses and granites, with intrusive dykes, and the small areas of reddish granite mentioned as being near the height-of-land and in the vicinity of the Mic-kai-ame Fall. A strongly banded gneiss is found on the lower part of White River and eastward beyond Sturgeon Lake, when granite of a light reddish colour, possibly intrusive, is followed by gneisses cut by many dykes of granite. The head of the eastern branch explored above Goose Lake, is in a small lake of which the shores are mostly composed of red granite. This extends southward to near Sha-boom-ene Lake, where gneiss is again found in contact with Huronian schists, the contact being of a broken nature, generally following the strike of the schists to the south-west. Angular patches of dark rocks are found, included in the gneisses as at other localities previously described.

Granite Areas of the South Shore of Red Lake.

The following notes refer to the granites of the south shore of Red Lake :—

Granites surrounded by Huronian rocks.

The first of these, near the outlet of Red Lake, is altogether surrounded by the Huronian of the Red Lake area. The contact as far as it could be traced among the islands, is evidently that of an intrusive mass breaking up through a bedded series. Fragments of the beds are included in the granite and alteration of both fragments and adjoining beds is also a feature.

The south shore of the western half of the lake, is also found to be of red granite of about the same general aspect, being light in colour and rather fine grained. This appears to penetrate into fissures and cracks in its contact with the Huronian. The line of contact which crosses the arm of the lake, touching the north shore and cutting off points, is found to take a somewhat sinuous course. The break does not always follow the bedding of the schists, but in many places is seen to cut across them at various low angles.

This mass is probably surrounded by the schists and greenstones of the Huronian, making a long oval area lying east-and-west, as at the

western end the schists are striking to the south of the granite area, and again on the south side, green fine-grained beds readily correlated with the clastic rocks of Red Lake, are met just north of Medicine Stone Lake. This probably forms a narrow belt, which, passing north of Bug Lake, joins the main mass on the west side of Keg Lake.

Granite probably eruptive.

This mass, with a skirting of Huronian, resembles in shape those areas already mapped in detail near Rainy Lake, but the broken nature of the contact on the north side, would suggest a rather violent separation of the narrow band from the main series and the interposition of an eruptive mass of granite.

Highly altered schists.

Outlying bands of gneiss south of the narrow band of Huronian mentioned above, are possibly highly altered schists. These are seen on the north shore of Medicine Stone Lake, the south shore of Upper Medicine Stone Lake, and on the stream south-east of a small lake lying to the west. Other masses of the red granite are found between the two Medicine Stone lakes and on the small lake to the west. The relation of these isolated areas of granite to the Laurentian gneisses of the region to the south-east has not been clearly determined.

Huronian.

Comparison with Lake of the Woods and Rainy Lake.

The series of schists, limestones and bedded materials originally of volcanic origin, here mapped as Huronian, in many respects lithologically resemble the larger areas to the south which have been designated by the local name Keewatin ; but the presence of dark-blue limestone and of conglomerates with jasper pebbles, both very similar to those of the typical Huronian area north of Lake Huron, renders the propriety of extending the name Keewatin to these rocks doubtful. The Coutchiching, supposed by Dr. Lawson to underlie the Keewatin in the Rainy Lake country, is possibly represented here by the small area west of Shallow Lake, but strata which most resemble the typical rocks of this series are found on Gull Rock Lake, and are seen to be only highly altered beds in contact with the Laurentian, which when followed along the strike, away from the contact, change very materially and resume the general aspect of the rest of the Huronian.

The contact with the gneissic rocks and granites of the region was found to be generally of a brecciated character, the gneisses and granites while in a plastic condition surrounding and inclosing the Huronian schists.*

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* With further reference to the nature of the contacts or lines of junction here described, and the inclusion of Huronian fragments in the gneissic rocks, see Lawson's reports on the Lake of the Woods and Rainy Lake. Annual Reports, Geol. Surv. Can. (N.S.), vol. I., p. 62CC and vol. II., p. 23F.

Rocks of the Shallow Lake Area.—As before noted in the Summary Report for 1883, a small patch of Huronian rocks was seen on this lake by Dr. Bell. The junction of the Laurentian gneisses with these rocks occurs on the west shore, at about three miles and a half north from the outlet. Gray gneiss, striking westward, occupies the shore to the first large bay. On one of the islands in this bay on which the Indians have small gardens, is a series of black gneisses very much twisted. On the mainland opposite, the gray gneiss gives place to dark gneiss very much seamed with granite veins, and in the gneiss are included fragments which apparently are broken from the darker series. The exact point of contact was not seen, but the attitude of the beds on each side, is that of a dark series very much twisted up by heat and pressure, becoming broken and fissured and finally disappearing in a much altered condition as fragments held in the mass of adjacent gray gneissic rock of which the strike is directly across the general trend of the dark beds.

Shattered contact with gneissic rocks.

Following the shore northward, the beds very soon loose their folded character and are found with a uniform strike to the north, afterward turning to the north-east with an easy curve. The general trend of the series is nearly parallel to the shore-line, so that the bed which is found at the mouth of Red Lake River would cross the points at the north-west corner, touching the shore at the bottom of the bays, thence turning south, would pass just clear of the west side and finally would be crumpled up near the contact, thus on the lake shore a very narrow section of the series is found. In going westward, this section consists of, first, dark semi-crystalline schists or gneisses, a band of dark-green hornblende-rock, in places rendered schistose and in others mainly a trap, and lastly the beds at the mouth of the river, which are a dark-green, fine-grained rock, well stratified and apparently clastic, resembling beds within the larger Huronian areas. On the river, few exposures are to be seen. At the foot of the first rapid, dark hornblende-schists are exposed, followed in a short distance, at the second fall, by coarsely-crystalline hornblendic eruptive rock, which is similar to that on Shallow Lake. The thickness of the section can scarcely be estimated, as the western boundary was not seen, but the presence of angular granite boulders, which had evidently not been carried far, containing inclusions of dark rocks, would place this line just above the second rapid, or at a distance of two miles from the mouth of the river. A small eastward extension of the series is found on the narrow point separating the two Shallow lakes. These beds have an average south-west strike and appear to have formed a nearly separate area from the rocks of the west shore, while a series of granites with a varying

Huronian of Shallow Lake.

amount of foliation has occupied the gap between, which is probably one main break with several lesser ones in the form of dykes, generally cutting into the mass along the bedding planes. The islands in the centre of the lake and near the east shore are all of gneissoid granite. The main shore at the outlet of Little Shallow Lake, is a light granite with greenish tinge and numerous small crystals of light-green hornblende. This rock probably occupies the trough or valley of the connecting stream, as it is found again at the mouth, on Shallow Lake.

Rocks of Little Shallow Lake.

The Huronian rocks extend to the eastward on Little Shallow Lake, nearly to the mouth of Trout Lake River and occupy the west shore to near the south-west corner. The division line passes not far from the west shore making a light curve. The long point from the east shore appears to be mainly reddish granite and the small island opposite, near the shore is composed mainly of gneissoid granite. At the contact, near the south-west corner of the lake, the beds are found to show a great amount of metamorphism which decreases as the line of contact is left. A coarse-grained, whitish, gneissic granite containing silvery scales of mica and whitish felspar, is found in contact with a dark gray gneissic schist, which is succeeded by dark-green rusty-weathering coarse-grained schist and a dull fine-grained gneiss. The shore northward for a couple of miles, is occupied by a fine-grained, dark gneiss which resembles that of the west shore of the larger lake. From opposite the long point to the outlet, several beds are found of a dark, fine-grained stratified rock containing a great amount of magnetite and specular iron. These beds may prove to be of future use as ore-deposits.

Rocks of Trout Lake River above Little Shallow Lake.

The north-eastward extension of the series, follows the high ridge west of Trout Lake River, crossing this stream somewhere below the big fall. The first exposure is of a light grayish-green, quartzose mica-schist, which is probably a squeezed gneiss. This is associated with beds of a dark green to gray fine-grained material which is probably an altered sedimentary rock.

The granite dyke which breaks into the mass at the fall, is followed above, on the river, by dark-green hornblende-schists, and by a coarser crystalline hornblende-rock resembling the bands of eruptive rock on the north side of Shallow Lake. The northward extension above, is hidden, and we next see the granites which extend to Trout Lake. It is quite possible that the beds, which here are striking north-east and south-west, may continue to the north-eastward and join the area of Huronian exposed around Woman Lake, but of this there is no certainty.

Rocks of the Woman Lake Area.—Our explorations in this district were along two routes near together and probably at the extreme western edge of the Huronian area, as the beds very likely run much farther to the eastward than we had the opportunity of seeing.

Our routes were from Shaboomene Lake (in the Cat Lake basin) through Woman Lake and down the Trout Lake River, and again from Trout Lake eastward via a long narrow lake to Woman Lake, thence up stream to Clearwater Lake (lying east of Woman Lake), directly south up stream to Fly Lake and thence down by the Wenassaga River to Lac Seul. On the former route, we met with the western boundary of this series on the Shaboomene Lake, where a series of foliated granites are found in contact with dark-gray schists and garnetiferous gneisses, which appear near the western border of the series. The gneiss is cut by dykes of light coloured greenish-gray trap which is not seen in the foliated granites to the north. The beds following this are of green schist. The western boundary of the Huronian, includes a narrow strip along the west shore and cuts across a bay to the south side of the lake, leaving the northern part and a small patch on the south-western side, in the Laurentian; while part of the west shore, the south and the southern half of the east shore are composed of Huronian rocks. The bay at the south end, from which the portage is made, is surrounded by rather steep shores of light-green altered volcanic rocks, fine-grained and compact, with many small shrinkage cracks filled with calcite.

Contact of Laurentian and Huronian on Shaboomeme Lake.

The portage to a small lake above Woman Lake is over a high ridge of dark green, squeezed and altered quartz-porphyry. The same bed is found again on the north end of Woman Lake on a continuation of the strike to the south-west. Down the west shore, the succeeding beds are evidently of volcanic origin—light-green diorites and ashy-weathering agglomerates. Near the south end, at the narrowest part, a dark series of cherty rocks follows the west shore and passes away to the south-west, followed again at the bend by beds of dark fine-grained thin-bedded rocks, of which some are thoroughly filled with iron-pyrites and magnetite. Medicine Rock, just out of water in the centre of the channel, is apparently a mass of ore, while the weathered pyrites supplies the Indians with "medicine."

Huronian of Woman Lake.

In the river at the outlet of the lake, the last rock-exposure is of a dark green-felsite, and on the first lake below—Little Bear Lake—the rock is a gray gneissoid granite with included fragments of a dark colour which were supposed to be highly metamorphosed pieces from the Huronian.

Rocks of route from Woman Lake to Trout Lake.

The route from Trout Lake through this area, is up a very small stream to the eastward for about five miles to a small lake. Here dark, green eruptives are seen, but the portage of two miles to the south takes us back again into gneiss, and the long lake there reached runs along the strike of these rocks. The contact with the Huronian occurs on a narrow strait leading northward to another arm of this lake, and its occurrence was indicated in advance by the presence, in the gneiss, of an increasing number of dark patches, apparently inclusions.

The attitude of the beds is somewhat similar, the schists first found dipping north $< 45°$, while the gneisses near the contact are very nearly in the same position.

Along the eastern extension of this lake the rocks are principally green, and massive but, in places rendered schistose by pressure and then frequently splitting into thin plates. Near the eastern end, seams of white calcite are found generally interlaminated with the beds, but sometimes breaking through them and holding fragments from the sides. The massive green rocks often show small blots and lenticular patches of easily weathered material, which leaves cavities on the surface. On the portage to Woman Lake, the rock has the appearance of having been very much shattered and subsequently squeezed into schists along the lines of fracture.

Huronian of Lower Clear-water Lake.

On the first Clearwater Lake, the rocks near the north end are massive green diorites, but toward the south they become more schistose and the bedding or cleavage runs south-west parallel to the general direction of that on Woman Lake. Very fine grained, gray-green, massive looking porcellanous rock, breaking with conchoidal fracture, is found on the last portage leading to the second Clearwater Lake. This was not seen in contact with the rest of the series, but is probably one of the eruptives found in the Huronian. At the south end of the lake, a light yellowish-green, squeezed quartz-porphyry occurs, which is very similar to the beds at the north end of Woman Lake.

The course of the river, through the string of lakes, has been somewhat parallel to the strike or bedding, but from Clearwater Lake eastward, for two miles, it cuts across this direction, and another series of long narrow lakes is drained. The first of these lies in a north-east, and south-west direction, with a narrow bay extending two miles to the south and connecting by a small stream with another long narrow lake lying further south. The rocks here are rather fine-grained greenstones, with a fine porcellanous surface of fracture.

Rocks of Fly Lake.

At the portage to Fly Lake, a light-green rock, evenly spotted with ash-coloured irregular markings on the weathered surface, is found. It

is uniformly dark-green on fresh fracture, a coarsely crystalline hornblende-rock in which the bedding could not be made out.

Fly Lake lies in the same trough as the lake north of it, and runs nearly north-and-south, the strike of the rocks following nearly the direction of the shores. At the north end, a dark-green massive rock prevails. Toward the south end, fine-grained bedded rocks which have the appearance of being altered sedimentary materials are first met with.

The strike of the beds is to the south, but near the south end of Fly Lake this turns south-south-west, and on the Wenassaga River to the east, varies from south-south-west to south-west.

On the portage eastward from Fly Lake, light-green quartzose beds are followed by coarsely crystalline hornblende-rock. Down the stream, dark hornblende-schists are seen on the side of the valley, and on the long portage to Wapagase Lake, several ridges of the same dark-green coarse hornblende-rock are crossed, while at the eastern end, near the lake, schists are found which are apparently of the same composition, but show a secondary crystallization of the hornblende, a common contact phenomenon. Rocks of west branch of Wenassaga River.

A few exposures of a thin bedded quartzite or quartzose schist are to be found at the small rapids below, all striking south-west to west-south-west, and at the little lake near the mouth of Sand-bar Lake, gray gneisses, which possibly belong to the Laurentian, occur. The junction between the two formations was not seen, and the exact southern boundary of the Huronian was therefore not established. Laurentian of Wenassaga River.

The western outline of the area of Huronian rocks above described is probably very sinuous, beginning to the west of Shaboomene Lake, making a long point toward Trout Lake and taking in part of a long narrow lake, then forming a long tapering arm including Woman Lake and touching the eastern end of Little Trout Lake, with a very uncertain southern edge, reaching to near the Sand-bar River branch of Wenassaga River.

Rocks of the Red Lake area.—The Huronian area of Red Lake and vicinity is, on account of the greater variety of rocks included by it, of more interest than those previously described. The exact boundaries of its rocks are determined only by those exposures of contacts which are to be seen on the lake shore and on the streams explored, so that the connecting lines between such exposures are necessarily somewhat uncertain. The northern side of the lake touches the Laurentian only on Pipestone Bay, and on Whitefish Spawning River the contact is a short distance from the lake. The boundary is thus conjectural between these points. To the south, the boundary is seen at several Boundaries of the Huronian.

places on the lake, as appears by the map appended. There two large oval areas of granite come up through the Huronian rocks, and these granites, by the nature of the contact, are evidently intrusions. The complete section was not worked out, owing to lack of time.

Section on Pipestone Bay.

The western bay of the lake, Pipestone Bay, affords the best opportunity of studying an almost continuous exposure of the beds across the strike. It was found to present, with Trout Bay to the south, a series of highly inclined beds representing possibly many folds which have assumed the general form of an anticline, the axis running east-and-west occupying the area of Pipestone Bay. The beds on the north, in contact with the gneiss, dip northward at angles varying from 60° to 80°. At the centre and near the south side they are nearly vertical. Southward through the narrows, the inclination is south varying from 50° to 80° from the horizontal. A synclinal fold with its axis running north-west, brings the beds up again on the south shore of Trout Bay, where they strike along the general direction of the south shore of this arm. The continuation of this to the south-east probably forms a narrow belt, passing near Medicine Stone Lake and joining the same rocks at Gull Rock Lake.

Rocks represented.

The composition of the series in these folds appears to be as follows, in ascending order :—

1. Dark green schists, probably squeezed volcanic material, together with a more crystalline hornblende-rock which appears to be eruptive.

2. Yellowish-white, rusty-weathering, dolomitic limestone holding irregular nodules of a cherty nature. These beds in some places are more or less quartzose owing to the greater or less prevalence of the cherty masses. Alternating with them are greenstones which are occasionally altered to a soft chlorite or pot-stone, the pipe-stone of the Indians. In this form, an example is found in the narrows leading to Pipestone Bay, where a bed of one foot in thickness lies between beds of rusty dolomite.

3. Beds of slate and schist, mostly black and dark-green, are found to intervene between the first rusty beds and a second series above.

4. The second series of rusty-weathering dolomites is preceded by a bed of squeezed and altered quartz-porphyry of ten feet in thickness. The dolomite is in a thicker bed, and, like the first, very much spotted with dark-weathering irregular masses of cherty or quartzose material.

Above this is another band of altered quartz-porphyry, which is in the form of a gray hornstone with numerous blebs of quartz.

In other parts of the section, these beds can be with difficulty followed, but may become altered to varieties of slates, schists and quartzites, while layers of greenstone, perhaps of volcanic origin, are found interstratified or forming lenticular masses between the beds, often seemingly occupying the place of other members of the section. Further extension of these bands.

The beds crossing the central portion of Pipestone Bay, possibly representing the lower members of the series, are nearly altogether of alternate layers of greenstone and green schists, often becoming a chlorite schist. Succeeding them to the north, a series of highly quartzose felsites, occupying probably a similar position to the lower dolomites of the south side, weather to light colours and assume the appearance of quartzites.

In the northward extension, which should represent the upper part of the section, the first band of altered quartz-porphyries and cherty dolomites only, are found in contact with a band of dark diorites and hornblende-rocks, which extends to the contact with the Laurentian.

In a bay just north of the Wolf Narrows, a band having the appearance of a conglomerate is found, with occasional pebbles of red banded jasper and others of a light-yellowish quartzite, but the majority of the pebbles are of a dark purplish-gray to green with a matrix of the same colour. The thickness of the band is about ten feet, and the associated rock is of a greenish to gray colour in rather thin beds. The position of this bed is probably represented by a band of conglomerate, which follows north of the slates exposed on the north side of S ate Bay. These slates, a fine-grained argillite in composition, are generally black and thin bedded, with many jointage planes dividing them into small pieces less than a foot in length. Conglomeritic rock. Argillite.

At the eastern end of the lake, dark blue limestones are found associated with these beds, but as the strata there are apparently much folded, the relations of the two classes of rock could not be ascertained.

The rocks on the south shore of Granite Bay, as well as the points on the north, are all of a light reddish granite in which the foliation is very slight. Wherever noted, this is nearly parallel to the general line of the northern border, dipping towards it at a low angle. Limestones.

The line of contact of the Huronian schists is seen in many places, beginning on the west at the narrows from Trout Bay, where it cuts off two small islands lying in front of the opening. Thence it crosses Marble Bay, and the beds on the point to the east are cut at an angle of 45° by the granite, which occupies the point and also the western face of a small round island where the schists abut directly on it. Huronian contact with granites.

The large island to the south, is mainly granite, with only the slender point at the east end, of Huronian. At the Wolf Narrows, both shores are granite, the line of contact following nearly the line of bedding of the schists, and cuts off the northern point. In the bay to the east, the granite has been eroded to the contact-line, and along the shore small patches of it are found clinging to the face of a high cliff, while seams of the same material occur, running north into the mass of the darker rocks. This shore is thus chiefly composed of Huronian rocks, but generally represented by a dark crystalline rock which looks somewhat like a diorite squeezed in some places to a crystalline schist.

The granite of the south shore is replaced at the Middle Narrows by black schists and dark-green rocks which strike south-by-east, apparently the same beds which border the north shore of the bay to the east. The contact line bends around from the north shore, touching the islands, and strikes the south shore just south of the narrows. There the contact is a sharp line running with the strike, but having a few parallel dykes of granite, apparently filling breaks made along the bedding near the contact. A few scattered dark angular fragments are seen in the granite.

Marble

The rocks of Marble Bay, on the north, are continuations of the altered quartz-porphyry and rusty cherty bed which is seen directly to the west. These are followed to the north-east by fine-grained light-green altered rocks and by a small area of white calcite with many dark irregular markings which are very similar to those in the yellow beds before mentioned. This area of white marble-like rock, does not seem to form a well defined bed, but looks rather like an irregular mass. At the end of the bay, dark crystalline rock is seen, altered to a serpentine or something of that nature.

Slates and agglomerates.

The eastern part of the lake is divided into two parts by a string of islands, with a large one, Mackenzie Island, at the north end. The northern part forms a long narrow arm running to the north-east and is named Slate Bay, from the many exposures of this rock running parallel to the north shore, and also exposed on the north shore of Mackenzie Island. The slate band of the north shore is found to be flanked on both sides by agglomerate. That on the south side is a dark-green mass, in which large lumps of slightly harder rock are cemented together by material similar in colour, but weathering somewhat more readily. Fractures along the bedding show a very lumpy surface. This bed may prove to be of volcanic origin, and it was recognized in two places, on a point at the west end of the bay and on another opposite Mackenzie Island.

On the northern edge of the slate band, a narrow strip of lighter coloured slate, holding lumps or grains of quartz, was found. The possibility that this is a much squeezed and altered quartz-porphyry, is suggested not only by its appearance, but from the position it seems to occupy in the section, where it is apparently a continuation of the bed seen on Marble Bay. This is followed northward by a bed of argillaceous slate, making a total breadth for the slate bands of nearly a quarter of a mile.

A band of cherty rocks, holding pebbles of much the same nature, occurs at the north side of a bay near the west end, and again appears north of the slates, in a deep bay northward from the centre of Mackenzie Island. Still farther north, after passing some dykes of fine-grained diorite, similar pebbly rocks are cut by granite dykes, which are apparently offshoots from a mass that seems to compose the hills at a short distance north of this arm.

Limestones and schists of Mackenzie Island.

On the north end of Mackenzie Island and on the mainland to the east, dark blue limestones are found associated with dark schists. These rocks strike to the south of east on Mackenzie Island, but north-west this changes gradually, till in the narrows leading to Whitefish Bay, they are running north-east and parallel to those on the north side. They seem to form a broad curved band coming from East Bay and abutting on the schists and slates of Slate Bay. In the narrows above, the rocks are fine-grained, black schists, and in East Bay the principal rock seems to be a dark-green schist, which maintains a nearly uniform strike of south-east by south. On the west shore are dark greenish-blue limestones, followed by yellow rusty-weathering cherty dolomites or limestones, which are probable continuations of some of the limestone beds of Mackenzie Island. The attitude of these is generally vertical, but occasionally they dip to the west. On the eastern shore of East Bay several large dyke-like masses of granite, generally light-gray, cut the beds, and probably indicate the proximity of the granite which occupies the shores of Trout Lake to the east.

The northern point of Mackenzie Island shows beds evidently very much disturbed. Their strikes converge on a point just west of the island, dipping on the north point at a high angle to the north, to the south of this point, towards the south, and lastly, along the western shore, they dip to the west, apparently passing under the slates exposed on the west side of the island. The position of the dark-blue limestones would appear to be lower in the series than the slates though as there is possibly a great dislocation as well as folding, this is uncertain.

Intrusive granite mass.

The bay to the south, or near the outlet of the lakes, is found to have been eroded through the centre of an oval area of intrusive granite, which occupies a part of the south shore, several small islands in the middle, parts of islands near the outlet and the southern part of Mackenzie Island. The contact with the Huronian on all sides shows the intrusive nature of this granite mass.

The schists on the south, strike approximately parallel to the contact, following around the granite, while on the east and north, the beds are more broken up and have been replaced by the granite. Part of the beds which pass to the south do not reappear on the west, and are evidently broken off. The main mass of the rocks of the south shore, west of the granite, are black hornblende-schists and eruptives, and these beds are seen again at the outlet and thence to Keg Lake, but a series of fine-grained greenish-gray, thinly laminated, chloritic schists, with lenticular patches and thin partings of calcite, lie to the north. These end at the granite, appearing only on its eastern side.

Huronian of Keg and Gull Rock Lakes.

Rocks of Keg Lake and Gull Rock Lake.—On Keg Lake, beside the dark schists, a very quartzose, fine-grained, black rock holding crystals of quartz, is found at the outlet, followed by spotted green rocks, which may prove to be volcanic agglomerates. Near Gull Rock Lake, after passing fine-grained green eruptives, we find dark green schists at the west side of the lake in a vertical attitude, striking about west-south-west. These beds occupy the eastern part of the narrow neck separating the two lakes, and probably cross in that direction to the west. A mass of granite is found on the extreme south-eastern end of this point. Farther north, beds which are continuations of those on Keg Lake and the river above, are seen crossing the lake, but possibly do not extend much farther. On the small lake to the northward of Gull Rock Lake, a small portion only of the shore is of Huronian rock, as the main part to the north-east is of granite and gneiss.

The schists on the west shore near the outlet, seem to be vertical, running north-and-south, while a short distance northward, they run east-south-east and west-north-west, showing a good deal of disturbance near their eastern contact with the granites.

On the islands in the southern part of Gull Rock Lake, masses of dark schists are found everywhere in contact with the granite, and often completely surrounded, so that the contact line is nowhere definite. The exposures are small, but the larger pieces of bedded rock appear to preserve their strike, so that many are possibly beds separated by finger-

like intrusions of the granite ; but on nearly all the islands many fragments are found completely inclosed in the granite.

To the south-west, somewhat the same appearance is noticed, especially on the river coming from Bug Lake. Fragments are there found in the granite, forming a belt of broken gneissic and granitic rocks, which borders the Huronian along nearly its whole southern and eastern limit.

Superficial Geology.

The surfaces of the Archæan rocks in this area are all more or less rounded and sometimes polished by glacial action.

Glacial striation.

Striæ are not well preserved on the surface of granite and gneiss, but in sheltered spots, as under boulders, they can be made out. On the finer-grained rocks of the Huronian, the surface is generally highly polished and the striæ are more distinct. The general direction is 22° to 40° west of south. The variations are caused by deflections in the direction of valleys or depressions through which the ice flowed. On the higher ground, the direction is more uniform and averages S. 30° W.

Superficial deposits.

The material left by the glacier is of two types, an unmodified till or boulder-clay, and a stratified or re-assorted deposit in the form of fine clay, silt, and stratified sands. The till is found rather sparingly spread over nearly the whole area, immediately on the surface of the harder rocks, and has been in turn covered, in some localities, by the stratified sands and silts. A high ridge of sand, boulders and well rounded gravel, is approximately the northern and eastern boundary of these silts.

Important morainic ridge.

This ridge, or series of ridges, as found bordering the south side of Trout Lake, is seen again south of Little Trout Lake, and crosses the valley of Trout Lake River above the first rapid. Hills which are supposed to be similar in character, are seen south of Sand-bar Lake on the Wenassaga River, and it is believed that the ridge may extend eastward to the head of Lac Seul. Northward, its extension is uncertain, but the Indians report a continuation from west of Trout Lake to Berens River at Mick-kai-ame Fall or just east of Sturgeon Lake, where there is a ridge of sand and gravel with boulders crossing the valley.

Its character

The top of the ridge, south of Trout Lake, is a series of closely placed narrow hills or parallel ridges, steep on the northern face and more gradually sloping to the south, averaging about 270 feet above Trout Lake or 1575 feet above the sea. The material seen on the northern

slope is sand and gravel with rounded boulders. Several steps or terraces, are also noted, but they continue but short distances, and from the lake no such continuous line can be traced. On the surface of the ridge, large boulders are found, the crest being well covered with them, but they occupy a narrow belt only, as the slope to the south, though less abrupt than to the north, commences immediately. The general appearance of the ridge is not that of an ordinary land moraine, but suggests a moraine or accumulation along the front of an ice-sheet terminating in water of considerable depth, in which the débris has been somewhat evenly distributed.

Deposits north of the ridge.

To the north of this ridge, in the Trout Lake country, there is a light coating of sand and gravel, but a much greater number of boulders is seen on the surface than to the south. The same in a less degree is true of the region to the east. On Trout Lake, the large island named Cat Island, is capped by, and appears to be mostly composed of sand and gravel similar to that of the big ridge, and is of about the same elevation. Other hills immediately north of the ridge may possibly be of the same nature.

Deposits south of the ridge.

South of the ridge, the boulder-clay is found in a great many places to be covered by stratified deposits, and a number of occurrences may be cited.

On Lac Seul, at the Hudson's Bay Company's post, terraces of sand show sections on the lake shore of twenty to thirty feet of clearly stratified beds with clay partings. In one instance, several feet in length of a thin bed is contorted, evidently from the pressure of a large mass of floating ice. The beds beneath and above are not so disturbed.

On the south shore, cliffs of sand, which reach a height of about eighty or one hundred feet, are apparently continuations of the terraces at the post, and are no doubt stratified likewise.

On Wenastegao Lake, just north of the western end of Lac Seul, stratified beds of sand, fifteen to twenty feet thick, are seen on the eastern shore. The valley of the Mattawa is characterized by stratified material containing more clay or silt, but capped by sands at about the level of Lac Seul. Again, on the streams coming from the north, the country cut through is found to have a considerable depth of stratified deposits in the valleys, which, although partly river deposit, is nevertheless often spread over a wide plain, as at the east of Little Shoal Lake, and then seems to be earlier than the present river-valley.

On Gull Rock Lake, beds of sand averaging twenty feet are shown in cliffs on the south-west side, and similar deposits are also found in some

parts of Red Lake. To the south, on Long-legged Lake, there is not apparently so much of this stratified material, but local examples of sand-banks are found on the English River below Mattawa.

Origin of the southern deposits.

It might seem probable that the high ridge to the north indicates the eastern limit of the great glacial Lake Agassiz, because of its great elevation and the undoubted lake-deposit on its western and southern front. There appears to be, however, no definite information that these deposits continue beyond the basin occupied by Lac Seul, Shallow Lake, Gull Rock Lake and Red Lake, and they may thus indicate a lake of much smaller dimensions. At present, there seems no reason to suppose that the outlet of this basin through the valley of the English River, had ever been dammed up to a greater extent than eighty feet by morainic deposits, but a possible barrier might have been formed by the presence of two small confluent glaciers on the higher ground on either side.

Ridges near Shallow Lake.

Between the hills bordering the west shore of Shallow Lake and the ridge running north-east from the northern end of the lake, there is a wide, low flat, through which the Red Lake River runs, but two rather prominent hills seem partially to bar the exit of this stream, and it finally reaches Shallow Lake by making a detour to the east around them. They are seen to be narrow ridges lying about west-south-west and east-north-east, and from exposures on their slopes, are known to consist almost wholly of boulders and gravel, well polished and rounded. Their height above the surrounding low country was found to be about 170 feet. The crest of each, is a narrow ridge sloping abruptly on each side. Large angular boulders of gneiss and granite are found on the southern slope. The northern is in the form of three or four narrow terrace-like steps, showing only the well-rounded gravel and boulders on faces of the steeper slopes. The origin of these hills is probably the same as that of the Trout Lake ridge, except that the position and direction would appear and indicate that they are lateral moraines. Smaller ridges of morainic material are crossed or cut through by the same stream a short distance to the north-west.

Berens River basin.

In the valley of the upper waters of Berens River, the mantle of drift is of a variable thickness. On the height-of-land on the south and east, there seems to be very little but loose boulders, with some sand and clay. Lower in the basin, there is more sand with the same abundance of boulders. In one place on the lower part of White River, dark clay was found lying immediately above the rock, with sand on the surface.

Glacial markings and polishing are here again everywhere noticeable, but on weathered surfaces not very distinct. The general direction of glaciation appears to have been from the north-west. At the south end of Pekangikum Lake the striæ run S. 36° W., but further to the east on Fairy Lake, they run west, thus showing considerable local deflection.

At the first fall above Sturgeon Lake, a ridge of sand and gravel seems to be cut by the river. High banks of sand and gravel are shown at the portage and a ridge is said to extend to the south a long distance. On the White River, about south-west from the above place, the stream cuts through a deposit of sand and boulders. No section was seen, but the bed of the stream contains an increased number of boulders.

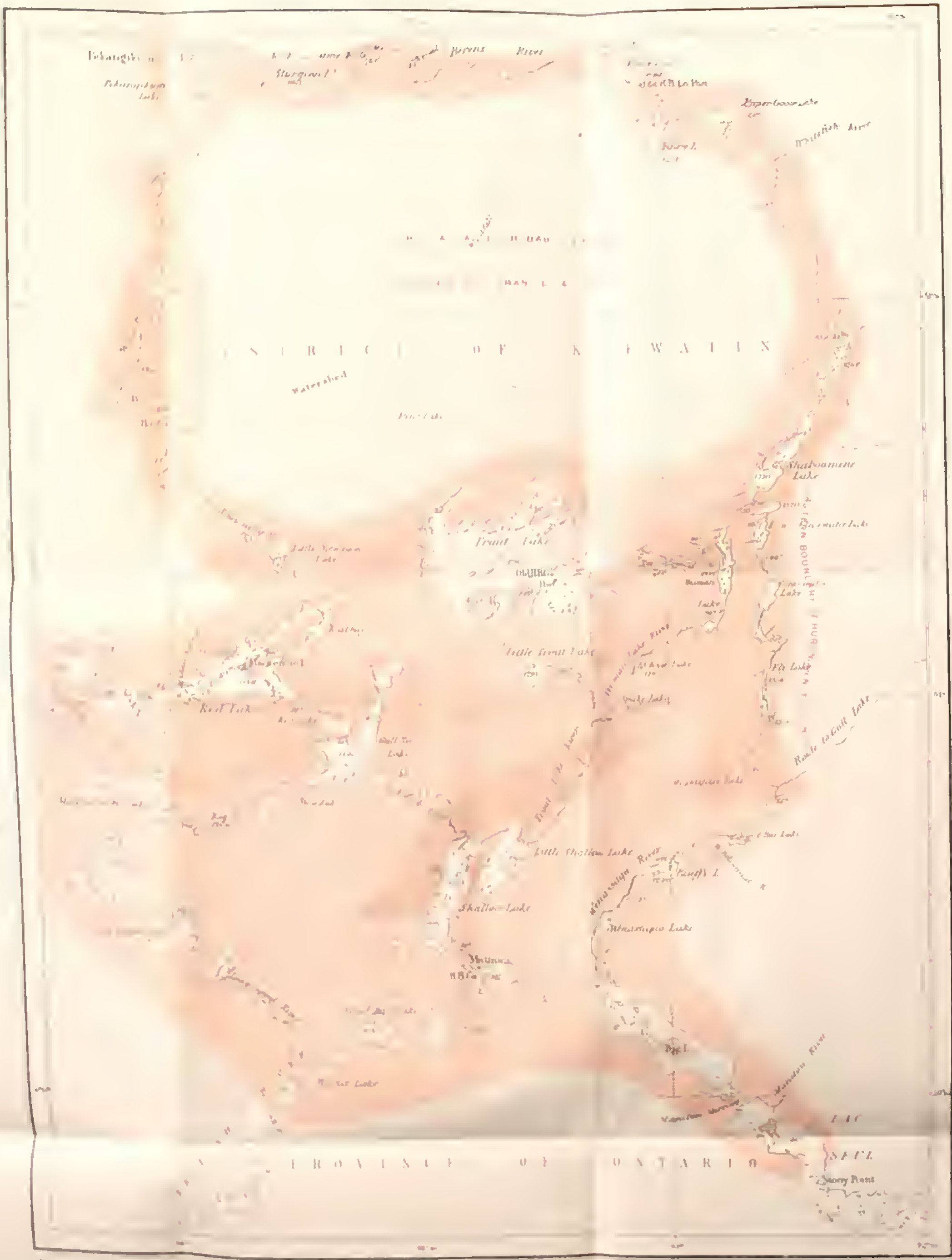
Lands suitable for agriculture restricted.

The agricultural possibilities of this valley seem to be limited, and the areas suitable for cultivation are only to be found in isolated patches. These are principally in the neighbourhood of the larger lakes. The Indian reserves have been located with this end in view as they seem to cover about the best land seen. The soil is a light gray clay with a little vegetable mould, and the gardens made by the Indians produce potatoes of fair quality, the only vegetable grown.

In the southern part of the district, better land is found and in greater extent than in the Berens River valley. On Lac Seul, at the mission and trading post, there are several very good gardens in a flourishing condition, with all the ordinary vegetables growing very satisfactorily. The Indians appear to care little for any gardening except a very primitive attempt at raising potatoes.

Land suitable for gardening was seen at Mattawa, and indeed the best and largest extent for this purpose is to be found between Lac Seul and Shallow Lake. The country is well covered by timber but of small average growth. The sandy-tracts are generally wooded by Banksian pine, but in the river-valleys and on the heavier land, poplar, birch and spruce are abundant. White and red pine are found in small groves south of Lac Seul and are of good average size for timber. On the lake are scattered trees of both varieties. The northern limit of Red pine extends to Red Lake, where a few trees were observed. Cedar of inferior growth occurs in isolated localities and extends north-west to the height-of-land, but none was seen within the Berens River basin.

Geological Survey of Canada



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GEOLOGICAL SURVEY OF CANADA

G. M. DAWSON, C.M.G., LL. D., F.R.S., DIRECTOR

REPORT

ON A PORTION OF THE

PROVINCE OF QUEBEC

COMPRISED IN THE

SOUTH-WEST SHEET OF THE "EASTERN TOWNSHIPS" MAP (MONTREAL SHEET)

BY

R. W. ELLS, LL.D., F.R.S.C.

With a Chapter on the Laurentian, North of the St. Lawrence River

BY

FRANK D. ADAMS, MA.SC., PH.D.

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY

1896

Dr. G. M. Dawson, C.M.G., F.R.S., &c.,

Director Geological Survey of Canada.

Sir,—I beg to submit herewith a report on the geology of that portion of Quebec contained in the South-west quarter-sheet map of that province, being the third in the series. It contains the results of observations made chiefly in 1889-90, but which, on account of unavoidable delays in completing the accompanying map, could not sooner appear. The vicinity of the lower Ottawa and the Island of Montreal have been recently re-examined, and the information obtained is incorporated.

A valuable addition to this Report, is the chapter descriptive of the Laurentian rocks of the north-west corner of the sheet, contributed by Dr. F. D. Adams, who has devoted special attention to that part of the region.

Extensive collections of fossils from various points throughout the area have been made by my assistants, Mr. N. J. Giroux and Dr. W. E. Deeks, and also by Mr. Whiteaves, Dr. Ami and myself. These have been examined and named by Dr. H. M. Ami, whose report thereon will be found in the form of an appendix.

I have the honour to be,

Your obedient servant,

R. W. ELLS.

Geological Survey Office,
Ottawa, Nov., 1895.

Note.—The strikes and dips in this Report are given with reference to the true meridian, the declination being about 13° west of north.

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FRANK D. ADAMS, MA., PH. D.

The present report comprises the results of the observations, made principally during the years 1889 and 1890, in the area included in the south-west quarter-sheet of the "Eastern Townships" series, or that portion adjoining the states of Vermont and New York. The area more particularly described is bounded on the east by Lake Memphremagog and by a line drawn thence north to the vicinity of Richmond, on the St. Francis River; and on the west by Missisquoi Bay and the Richelieu River. Careful examination, however, was also made of much of the flat country lying between this river and the St. Lawrence, but, owing to this area being largely clay-covered and presenting very few outcrops of rock, the geological results obtained are much less satisfactory than for the area further eastward, where rock-exposures are numerous. A re-examination was also made of the country along the lower Ottawa and the Islands of Jésus and Montreal, to obtain any additional details of structure which might be revealed by recent lines of railways or other works, such as quarries and excavations.

Area embraced in the report.

The examinations thus comprise the highly altered series of rocks seen in the Sutton Mountain anticline, which are the northward extension of the rocks of the Green Mountain range in Vermont, as also a very considerable portion of the Lower Palæozoic of the St. Lawrence basin on the west, and of the St. Francis and Memphremagog syncline on the east. The peculiar rocks of Phillipsburg, Stanbridge and Bedford were also carefully examined, in company with

Range of geological formations.

Mr. C. D. Walcott, now Director of the United States Geological Survey, and large collections of fossils were made by Mr. Whiteaves and by my assistant, Dr. Deeks, in order to ascertain, as clearly as possible, the exact position of these beds in the geological scale. These collections have been carefully worked out by Dr. Ami, Assistant Palæontologist, and the results of his examinations appear in the supplementary chapter. The area to the north of the St. Lawrence was more particularly studied by Dr. Frank D. Adams, of McGill University, especially with reference to the distribution of the anorthosites and their relation to the Laurentian rocks of St. Jérôme and the country to the north of that place.

Dr. Frank D. Ad ms's work.

The St. Lawrence basin.

The flat country between the Richelieu and St. Lawrence rivers, as well as that along the lower Ottawa, to the south and east of the Laurentian escarpment, has already been fully described in the Geology of Canada (1863). It includes the island and city of Montreal, where outcrops of the generally nearly horizontal limestones, shales, &c., of the Cambro-Silurian formations, together with the Potsdam sandstone, are in places well exposed; but over the greater portion of this flat country, rock-outcrops are rare, even in the river-beds; the surface being occupied by a very heavy covering, mostly of marine clays. Out of this, at isolated points, the doleritic mountains of Montreal, Montarville, St. Hilaire, Rougemont, Johnston and Yamaska, protrude abruptly and rise, in some cases, to elevations of 1200 to 1500 feet above the plain. Occasionally, however, ledges of stratified rock are visible, as in the Yamaska River at St. Hyacinthe, where the bed of the stream, for a distance of about a fourth of a mile, shows the presence of highly fossiliferous sediments of Hudson River (Lorraine) age. On the Richelieu also, at Chambly Basin, and in the River des Hurons, a short distance south of St. Hilaire Mountain, nearly horizontal strata, filled in places with fossils, are seen. The examination of the fossils recently collected, shows the age of these rocks to be that of the Lorraine and Utica formations.

Eruptive ma ses.

Work formerly done in he area.

A large amount of geological exploration has been carried out in this region in former years, in fact, almost since the beginning of the Geological Survey of Canada. The outlines of this work have already been briefly sketched in the earlier reports, and the bibliography of the subject given,* so that it will not be necessary to repeat these here. Since the date of the last official report on this district, however, in 1866, (which had more particular reference to the copper deposits of the area,) and the publication of the general geological map of Canada, of the same

*Annual Reports, Geol. Surv., Can., vol. II. (N.S.), 1886, p. 6 J; vol. III. (N.S.), 1887-88, pp. 25-48 K.

date, the views there expressed as to the structure of the Sutton Mountain region have been very materially changed. This change was due largely to the examinations made by Dr. Sterry Hunt, and later by Dr. Selwyn, and as a consequence the Sutton Mountain anticline, formerly regarded as of Sillery age, is now established as below the lowest fossiliferous sediments. More recent investigations of the formations lying west of the crystalline schists, have shown that the black slates and bituminous limestones of Farnham, instead of constituting a possibly lower portion of the fossiliferous Quebec group, are in reality a newer series; and presumably, from the contained fossils and from their stratigraphical relations to the underlying rocks, the equivalent of the lower part of the Trenton formation. In the stratigraphical sequence assumed in the Geology of Canada, 1863,* these black limestones and slates, of Farnham (when not fossiliferous) were regarded as older than the Lévis division of the Quebec group, and were put at the base, followed, upward, by the Lévis graptolitic series and then by the red and green slates and sandstones of the Sillery formation. This must now be reversed. The true sequence is in ascending order the Sillery, Lévis, (including the Calciferous of Phillipsburg), the Chazy of Stanbridge and the black slates and limestones of Farnham, Abbottsford and St. Dominique, which, at the latter place, graduate directly upward from the fossiliferous Chazy limestone into the Trenton.

Early view as to the structure of the slates and limestones.

Present view of structure of the fossiliferous rocks.

The several geological systems represented in the south-western portion of the province may be stated thus in descending order:—

Superficial deposits.

F. Devonian of Memphremagog Lake.

{ *E.* Silurian of the St. Helen's Island, Montreal, Lower Helderberg.
{ *E.* " " St. Lawrence Valley, presumably Medina.

D. Cambro-Silurian: Lorraine (Hudson River formation).
" " Utica,
" " Trenton and Black River,
" " Chazy-Trenton east of the Sutton Mountains axis, Farnham, &c.,
" " Chazy,
" " Calciferous,
" " Potsdam sandstone of the Ottawa and St. Lawrence basin.

C. Cambrian: Sillery red and green slates, sandstones and grits.
" Black and gray slates, east and west of the Sutton Mountain anticline.

Sequence of rmations.

* Geology of Canada, 1863, p. 240.

C. Cambrian: Georgia series of St. Armand (Lower Potsdam of the Geology of Canada, 1863).
" Lower Cambrian of the Sutton Mountain anticline.

A.B. Pre-Cambrian: Huronian of the Sutton Mountain anticline.
" " Laurentian limestone and gneiss west of the St. Lawrence River.

Crystalline and Igneous rocks, Volcanic and Plutonic.

DEVONIAN.

Devonian of the Eastern Townships.

Areas of Devonian rocks occur at several widely separated points in the area east of the Sutton Mountain anticline and its extension northward. The presence of limited outliers on the Chaudière River at St. George, Beauce County, and in Langevin, to the north-east, was mentioned in my report for 1887.* While detached areas of Silurian (Lower Helderburg) occur at a number of places between the Chaudière and the United States boundary, to the south-west, the only outcrops of strata holding typical Devonian fossils are found on the western shore of Memphremagog Lake. These have been briefly referred to in the Geology of Canada, but few details are there given as to distribution or fossils.

Memphremagog Lake, Sargent's Bay.

The survey of the shores of Memphremagog Lake, showed the presence of newer strata than those usually assigned to the Lower Helderberg formation, the limestones of which have a considerable development on both shores of the lower half of that sheet of water. Thus at Sargent's Bay, which is a deep indentation on the west side, distant ten miles from the outlet at Magog village, the fossiliferous Silurian is overlain by a series of brownish-gray, somewhat dolomitic flaggy slates and shales. These are well seen at a small brook about one mile west of the wharf at Knowlton Landing, and a careful examination by Dr. Ami, in 1894, showed the presence of Devonian fossils among which were recognized *Spirophyton* (*Taonurus*) *cauda-galli*, Van., *Psilophyton*, sp., and *Bythotrephis*, sp. The containing rocks dip at a high angle and certain bands hold crystals of iron-pyrites, evidently induced in the slates by the action of some of the numerous dykes from the neighbouring Hog's Back Mountain.

Fossils.

Mountain House area.

At the cove by the Mountain House at the Owl's Head landing, about six miles south of this place, plumbaginous limestones occur, and these extend up a gully in rear of the hotel. These limestones contain many well preserved corals, often of large size, of which collec-

*Annual Report, Geol. Surv. Can., vol. III., p. II. (N.S.) 1887-88, p. 10 K, Geology o Canada, 1863, pp. 251 and 436.

tions were made. Earlier collections from this locality had been examined by Billings, who pronounced them to be Devonian in character, and Prof. Dana, in the last, (fourth) edition of his Manual of Geology, describes these rocks as of Devonian age, quoting the authority of Billings and giving a list of fossils from the locality, which includes *Syringopora Hisingeri*, B., *Favosites basaltica*, Goldf., *Diphyphyllum stramineum*, B., and *Zaphrentis gigantea*, Le Sueur. These are presumably of Corniferous age. He also mentions, on the authority of Hitchcock, *Atrypa reticularis*, which, however, may have been derived from the upper Silurian formation in the vicinity. The presence of these Devonian outliers is of special interest, as enabling us to fix, approximately at least, the date of some of the eruptive masses of this area. Thus, at the Owl's Head, the plumbaginous limestone on the beach, is beneath the black slates of the Cambro-Silurian series, which are presumably the lower Trenton, owing to an overturn of the measures, while the intrusive dykes which penetrate the Cambro-Silurian and Silurian slates and limestones, show that the intrusions and crumplings were subsequent in date to the Cauda-galli flags of Sargent's Bay and the Corniferous limestones at Owl's Head.

Fossils.

Overturned strata.

No well defined break between the upper Silurian (Lower Helderberg) and the overlying Devonian has been found, the conditions of deposition, presumably being similar to those in the Beauce district or in the similar beds of the Gaspé peninsula, described under the head of the Gaspé Limestone series in the Geology of Canada, as well as in subsequent reports.* In all these localities there appears to be a mingling of forms of upper Silurian and lower Devonian horizons, insomuch that it has been found very difficult, and in some cases impossible, to define the exact line of separation between the two systems.

Similarity to the Gaspé Devonian.

Silurian.

The areas of Silurian rocks found in this portion of the province are of limited extent. In addition to the basin in which the lower part of Lake Memphremagog is situated and which is probably the largest development of Silurian strata in south-western Quebec, outcrops of very limited extent are found on St. Helen's Island, Montreal, while in the flat country to the east of the St. Lawrence, and to the south-west of Becancour River, Silurian rocks of an older horizon occur.

*Geology of Canada, 1863, pp. 406-428. Report Prog., Geol. Surv. Can., 1880-81-82, pp. 3-16 D.D.

St. Lawrence River Area.

Silurian of the St. Lawrence Basin.

Of the last mentioned outcrops, it may be remarked that the strata consist for the most part of reddish, soft sandstones and shales which form several areas along the south side of the river,* the exact outlines of which are impossible to define, owing to the great mantle of drift sand and clay which occupies much of this part of the province. Outcrops, however, have been found on a number of streams, and the difference in the character of the soil over those portions underlain by these reddish rocks, as compared with the usually grayish soil formed by the decay of the Lorraine shales, enables their outlines to be at least approximately traced.

St. Francis River.

The most southerly of these areas was re-examined during the past season by Mr. N. J. Giroux, of this Survey, along the St. Francis River and the country on either side adjacent. On this stream the breadth of the reddish outlier was found to be about four miles, and its western edge is about seven miles from the junction of the stream with the St. Lawrence. Two outcrops of the characteristic shales and sandstones were observed on the St. Francis, the upper one on lot thirteen, Augmentation of Wendover, with a breadth on the stream of half a mile, the nearest underlying beds up stream being the fossiliferous grayish sandy shales of the Hudson River (Lorraine) formation. The second is about three miles further down, and is exposed along the river for several miles, the beds in both outcrops being nearly flat. The red beds do not appear on the Yamaska River to the south, the nearest rocks there visible being the gray Lorraine shales, with characteristic fossils, near St. Hugues, about ten miles below St. Hyacinthe.

Medina shales and sandstones.

The age of these beds is supposed to be Medina. No fossils, however, have been found in them, and their determination rests upon their unconformably superior position to the Hudson River beds and to the fact that pieces of the red sandstone are found in the dolomitic breccia which occurs at St. Helen's Island.

Lower Helderberg of St. Helen's Island.

The Silurian outcrop at St. Helen's Island, Montreal, is noticed in the Geology of Canada, pp. 355-56 and a few of the characteristic fossils there found are mentioned. The rocks of the island are described as "principally a conglomerate, the inclosed masses in which are sometimes rounded, but chiefly angular. They consist of fragments of Laurentian gneiss; of white quartzose sandstone resembling that of the Potsdam formation; of dark gray limestone, in some cases holding Trenton fossils; of black shale resembling that of

*Geology of Canada, 1863, pp. 205-206.

the Utica formation; and of red sandstone and red shale similar to those of the Medina. With these fragments are associated others of igneous rocks. All of these varying in size from a quarter of an inch to five and six inches in diameter, are inclosed in a paste of light gray dolomite, which weathers to a reddish yellow. * * * About two-thirds of the distance down the east side of the island, there occur two masses of dark gray fossiliferous limestone, weathering to a light gray; which are not magnesian. These are included in a length of about forty yards and are limited on the east side by the water of the river; they have a breadth of scarcely more than ten feet, and appear to run under the dolomitic conglomerate on the west side."*

Character of the strata.

A re-examination was made of the peculiar rocks of this locality during the past season (1895). The supposed conglomerate was found to be rather of the nature of a volcanic breccia, dolomitic, weathering a rusty-brown, but grayish on fresh fracture, and intimately associated with the Utica shales, which show on the south-west end of the island below high-water mark. They are, further, intersected by numerous dykes of grayish trappean rock which are evidently spurs from the mass of Mount Royal. The Utica shale at this place has been greatly altered, the bituminous beds along the contact being sometimes hardened or baked, or occasionally rendered thin and splintery with destruction of the bituminous matter, the rock becoming gray in colour, while the contained fossils are frequently completely pyritized. The Silurian fossils are all obtained from the small patches of limestone found with the breccia at the north-east end of the island. Several collections have been made from these in recent years, in addition to those obtained by Billings many years ago.

Volcanic breccias.

Fossiliferous limestones.

Among these later collections may be mentioned that of Prof. J. T. Donald, of Montreal, in 1880, who published a list† of fossils from the limestone, comprising sixteen genera and thirty-six species, peculiar to the Lower Helderberg formation, but including two species which pass upward into the Oriskany formation of the Devonian. This list has since been very considerably extended by Dr. W. E. Deeks, B.A. of Montreal, who made a very comprehensive collection from the limestones of the island in 1890, the results of which were published in the Canadian Record of Science, in that year,‡ in which the number of genera is increased to twenty-four and of species to forty-four. Dr. Deeks remarks: "Of these, thirty-three are common to New York,

St. Helen's Island fossils.

*Geology of Canada 1863, p. 356.
†Can. Nat. 1881, vol. IX., New Series, p. 302.
‡Can. Rec. of Science, 1890, vol. IV., No. 2, pp. 104-109.

sixteen to Gaspé and nineteen to the Nova Scotia series." Several of the species appear to be common to the Oriskany and Lower Helderberg, in which respect they resemble the beds of the Gaspé limestone series, as well as those found on the Chaudière.

Isle Ronde.

Isle Ronde, which is separated from St. Helen's Island by a narrow channel only, is formed of a similar volcanic breccia, and in the extreme north-east corner, below high-water mark, a small outcrop of similar Helderberg limestone occurs, the mass being from one to ten feet wide by thirty feet long. It has the aspect of being inclosed in the breccia which is apparently newer than the limestone with which it is associated. The lists of fossils from this area, prepared by Dr. Ami, will be found in the appendix. The horizon of these limestones, being that of the upper part of the Silurian or the lower portion of the Oriskany parallels them with the beds on the west side of Memphremagog Lake already referred to, where a somewhat similar transition has been recognized.

Utica shales.

The shales of the south-west or upper end of St. Helen's Island have yielded fossils of Utica age among which several species of graptolites have been determined by Dr. Ami, as well as an *Endoceras* and a trilobite, *Triarthrus Becki*.

Volcanic breccias.

Similar breccias to those found on St. Helen's Island, have been observed at several points on the Island of Montreal and on the adjacent islands. Since they have now been demonstrated to be volcanic breccias, of later date than the Helderberg limestone, and not sedimentary conglomerates, they may be removed from the Silurian division of sedimentary rocks.

Eastern or Memphremagog Lake Area.

Silurian of Memphremagog Lake.

East of the Sutton Mountain anticline, the Silurian rocks are confined to the shores of Memphremagog Lake already alluded to, and to a small outlying area extending both to the north-east and south of Sargent's Bay. The formation is here characterized by a considerable thickness of limestone, some of which is graphitic, while other portions are highly dolomitic, and are associated with dolomitic grayish slates.

In several places they contain an abundance of fossils comprising brachiapods and corals. On the east side of the lake, the most southern limit yet recognized is in the cove at Capt. Gully's house, the first outcrop being seen about seventy-five paces west of the wharf at that place. Thence they occupy the entire east shore of the lake to the outlet at Magog village and, crossing the Magog River, extend

to the north into the flat country along the valley of the Cherry River for several miles, occasional outcrops being visible in this direction. At the village of Georgeville, they have a breadth inland of about one mile, and are terminated in this direction by a small brook and a depression, on the south side of which the rocks are black and gray Cambro-Silurian graptolitic slates.

On the west side of the lake, the Silurian rocks occupy the entire shore from the outlet to the extremity of Gibraltar Point, which marks the entrance, on the north side, to Sargent's Bay, and they are here separated from the series of black and gray Cambro-Silurian slates by the small depression known as Austin Cove. On the south side of Sargent's Bay they again come into view, in contact with these slates, about 400 yards south of the wharf at Knowlton Landing; the contact being seen in a small cove at this place, and the Silurian rocks which are here highly fossiliferous and dolomitic are in a nearly vertical position. The breadth here is a little more than a mile, and the rocks can be easily traced almost to the forks of the road turning off across the head of the bay, where they are again in contact with the blackish-gray, pebbly slates and diorites presently to be described. The Silurian rocks along the shore of the upper portion of Sargent's Bay, are in part overlain by the Devonian beds already described, but the calcareous beds are well seen about East Bolton post-office, on the west, and at Peasley's Corners on the east, whence they extend in a narrow band to the north-east, through Millington, crossing the road which runs south from Orford Pond to the lake, at about lots ten to thirteen, range thirteen, Magog, and terminating in the wooded country to the north-east, a short distance beyond the road. The exposures of these rocks south of Knowlton Landing, are confined to a narrow wedge-shaped band. They are seen along the road running south towards Owl's Head Mountain, as far as Perkins Vale where they are in contact with the black and gray slate series, and they extend for about a mile further south in the depression to the west of the road past Owl's Head Mountain, being there apparently cut off by the doleritic rock of that mountain. They are also exposed on the several roads leading across to Mansonville, with a breadth of from a half to three-fourths of a mile. As a rule these Silurian beds have a nearly vertical dip and present the same character of limestone and dolomitic slates throughout.

Sargent's Bay and vicinity.

Area north of Sargent's Bay.

Area south of Sargent's Bay.

South of the Owl's Head Mountain wharf, on Round Island, the same dolomitic slates, in places changed almost to a talcose mica-schist, contain characteristic fossils of Silurian age. They are cut by dykes of green crystalline diorite or dolerite of precisely similar character to the rock of the Owl's Head Mountain. In the long island off the

Round Island.

mouth of Fitch Bay, the contact of the slates and diorites is also well seen.

Capt. Gully's Cove.

The rocks at Capt. Gully's Cove, on the east side of the lake opposite the Owl's Head, also contain corals similar to those found in the beds of Round Island. They are also cut by dykes of considerable size, not only of the greenish crystalline diorite but of a soft, green, talcose rock, which has now a schistose structure. To the south-west of Round Island, a somewhat similar soft, green, talcose rock is seen in connection with the Silurian fossiliferous sediments, on the shore of the lake above the light-house, and forms an exposure several hundred yards in width.

It may be here remarked of these peculiar rocks, that from hand specimens only, they might easily be mistaken for pre-Cambrian schists, and it is by their intimate and undoubted association with the fossiliferous Silurian beds alone, that one is enabled to pronounce definitely upon their age.

Black and gray slates of Fitch Bay, &c.

In addition to the areas of Silurian just described, the great belt of black graphitic limestones with black and gray slates, which is especially well developed along the south-eastern side of Memphremagog Lake, more particularly to the south of and about Fitch Bay, was formerly regarded as of upper Silurian or Devonian age, and the rocks further east, and extending thence northward to the Chaudière River, were also assigned to the same formation.* The reasons for changing the position of these rocks in the geological scale, have already been stated in my report for 1886.† Cambro-Silurian fossils, were in fact found not only in the limestones but in the slates of the same series.

Limestone of Magoon's Point.

The small area of limestone at Magoon's Point which is apparently faulted in between slates of Cambrian age, is of doubtful horizon. The rock is highly crystalline, quite as much so as some of the pre-Cambrian limestones, and the only fossils yet found are crinoid stems. It differs from the limestones of the Silurian in the vicinity, both in character, and also in the fact that the rock does not show the presence of corals, so common in the Silurian beds. It is presumably of earlier date, and may, for the present at least, in the absence of more conclusive evidence, be placed in the Cambro-Silurian series, possibly as an altered portion of the Trenton limestone formation.

Georgeville limestones.

The dolomitic slates and limestones of the Silurian, are particularly well exposed along the east side of Memphremagog Lake, for several miles on either side of Georgeville. They frequently form cliffs

* Geology of Canada, 1863, pp. 432-37.

† Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), pp. 11-17 J.

of considerable height, and their broad, flaggy character is well seen. They are occasionally thrown into abrupt folds, several of which are visible near the Georgeville wharf, but further north, in the vicinity of Oliver's Corner, they are nearly vertical, and large slabs, suitable for pavements or flagging, can be easily removed. To the south of Georgeville, the limestone forms a bold bluff for a couple of miles to the bay north of Allan's wharf, around the shore of which they are also well exposed. Near the head of this bay the strata are in places filled with corals, often of large size, and very good specimens may be obtained from this locality. The slaty portions are frequently schistose and the corals are drawn out and greatly flattened by the pressure through which this schistosity has been induced. Corals flattened in the same way are seen on the shore at Capt. Gully's and at Round Island. Fossils.

The structure of the Silurian in this area is that of a folded basin, resting, on either side of the lake, upon fossiliferous Cambro-Silurian or lower Trenton rocks. That the rocks of the whole series have been subjected to great metamorphic action since their deposition, is evident, not only from the highly inclined and often folded character of the strata, both of the upper Silurian and the underlying Cambro-Silurian beds, but from the presence of numerous dykes, often of large size, which cut the strata of both formations, not only along the lines of bedding but frequently transversely to the bedding or cleavage planes. This is further shown by the alteration of the Silurian fossiliferous beds from their ordinary conditions of calcareous slates and limestones, to that of talcose and micaceous schists in the one case, and highly graphitic and almost crystalline limestones in the other. Fossils were obtained from a number of points in the Silurian, among which may be mentioned, Knowlton Landing, Owl's Head, Round Island, Capt. Gully's Cove, Allan Bay and the road one mile south of Georgeville, at the crossing of the brook near the contact with the graphitic slates. The result of their examination will be found in the appendix to this report. Structure of the Silurian. Fossils

CAMBRO-SILURIAN.

The complicated structure of the Cambro-Silurian rocks of south-western Quebec, furnishes several problems of very great scientific interest. All the members of this system are apparently represented, from the Potsdam sandstone and Calciferous to the Hudson River or Lorraine shales. The physical characters of these where found in the eastern area, however, do not in many cases resemble those which prevail in the characteristic strata of the several formations as developed

in the St. Lawrence and Ottawa River district, where these rocks can be well studied. In regard to the contained fossils in the former also, it may be remarked of the lower members that, while in general aspect these resemble the typical fossils of the formations further west, there is often a manifest development of forms which cannot readily be compared with those which usually form the basis for palæontological determination, more especially as relating to the Calciferous, Chazy and lower Trenton horizons. The conditions of deposition in the area under consideration, have apparently differed very considerably from those which prevailed in the Ottawa River section.

Rocks and fossils differ from those of typical areas.

The elucidation of the structure of this area, throws some light upon the much disputed question as to the age of the rocks of the city of Quebec, as well as of those found on the Island of Orleans and at many points along the Lower St. Lawrence, which have been described in my previous reports on these districts,* as also upon the age and equivalents of the fossiliferous Lévis and Sillery divisions of the Quebec group.

Faults.

The district is traversed by extensive faults, among which may be more particularly mentioned the great St. Lawrence and Champlain fault† described by Sir Wm. Logan in the Geology of Canada,‡ which has been traced from the Vermont boundary, at the foot of Lake Champlain, to the city of Quebec, and thence down the St. Lawrence River along the north side of Gaspé Peninsula.

The Phillipsburg series.

In order that the somewhat complicated structure which prevails in this region may be more clearly understood, it will be necessary, first of all, to explain the structure and stratigraphical relations of what we regard as among the lowest rocks of the system, viz., those above the horizon of the Potsdam sandstone and known as the Phillipsburg series, hitherto described as a portion of the Quebec group; more especially, since it is now very generally admitted by all who have carefully studied this series, both along the Vermont boundary and about Quebec city and Point Lévis, that certain portions at the two extremities of the section can be readily correlated. Very considerable attention has of late years been paid to these rocks by geologists and palæontologists in the United States, among whom Mr. C. D. Walcott has taken a leading part, and their studies of the rocks in the Phillipsburg area as well as of the fossils obtained therefrom, have been extensive. Large collections have also been made by Mr. Whiteaves, Dr. Deeks and myself

Fossils.

*Report of Progress, Geol. Surv. Can., 1880-81-82, pp. 16-31 D.D.
†Annual Report, Geol. Surv. Can., vol. III., (N.S.), part II., 1887-88 pp. 48 K-84 K.
‡Geology of Canada, 1863, p. 234.

from various places in the Phillipsburg and St. Armand section and at Stanbridge, Bedford and Mystic, which have been carefully studied and classified by Dr. Ami (see appendix).

The rocks of this section have been very fully described by Sir Wm. Logan,* and it will therefore be unnecessary to repeat their characters in any detail in this place. At that time, however, it must be borne in mind that the views as to the stratigraphical sequence of the various divisions of the Quebec group were entirely different from those which are now generally received.

Early views as to structure.

Thus, the series of black limestones and slates, in places containing fossils but in others apparently regarded at that time as non-fossiliferous, which appear at several points (notably at Farnham, Melbourne, Danville, etc.,) were, from certain peculiarities of structure, regarded as for the most part of Potsdam age and held to underlie the fossiliferous Quebec group, which was then supposed to comprise the Lévis and Sillery divisions only. The Sillery, moreover, was regarded as probably newer than the Lévis—a point in structure which has since been corrected ; as it is now conclusively established that the Sillery red, green and black slates and grits are older, or stratigraphically beneath the Lévis slates, limestones and conglomerates.†

Farnham limestones.

The Farnham limestone series is now believed, from the evidence of the contained fossils, as well as on stratigraphical grounds, to belong to the horizon of the lower Trenton formation, so that in order to clearly understand the structure of this interesting group, one must completely reverse the stratigraphical sequence as formerly given and read upward from Sillery (upper Potsdam), Lévis and lower Phillipsburg (Calciferous), upper Phillipsburg, Bedford and Mystic (Chazy) and Farnham black slates and limestones (lower Trenton). At Lévis and Quebec, all these formations do not appear, at least not in such perfect development as in the southern part of the province, the Chazy proper being apparently, or for the most part at least, wanting, unless certain beds of the upper Lévis formation may be assigned to that horizon, which appears probable. The lack of uniformity of development may be accounted for by the great faults which affect the areas along the St. Lawrence River.

Stratigraphical sequence.

Area West of the St. Lawrence and Champlain Fault.

The newest rocks of the Cambro-Silurian system found in this area, are situated to the west of the great St. Lawrence and Champlain

* Geology of Canada, 1863, pp. 275-286, and 844-861.

† 1. Geology of Canada, 1863, p. 239-240.

2. Annual Report, Geol. Surv. Can., 1887-88, vol. III. (N.S.), p. 82 K.

fault, between it and the River St. Lawrence. They are evidently the south-western extension of the Utica-Lorraine beds which occur along the river on both sides between Quebec and Three Rivers. They are well characterized by fossils, which are found at several places, and of which very considerable collections have been made, as at St. Hyacinthe and St. Hugues, on the Yamaska River, Chambly Basin and St. Jean Baptiste village, (the latter on the River Des Hurons, which joins the Richelieu a short distance above Mount St. Hilaire), and at Chambly. Rock exposures are, however, rare throughout this entire area. Further north, on the lower part of the Becancour, opposite Three Rivers, a small collection of fossils was made in 1888, which showed the presence of the typical Lorraine shale formation at this place, and served to indicate the apparently uniform extension of these rocks throughout this area.

Utica-Lorraine.

Characters of the Lorraine and Utica.

The rocks of the Lorraine formation differ somewhat in character from those of the Utica. They are more sandy in texture, and are generally of a grayish colour, or have frequent beds of gray, sandy shales, which sometimes pass into sandstone layers. The Utica, on the other hand, is generally characterized by the presence of brown, or brownish-black, bituminous shales, with occasional hard bands of dolomitic limestone, but gray beds like those of the Lorraine are rarely seen.

St. Francis River section.

The most northerly outcrop of the Lorraine shales seen in the present map-sheet, was observed in 1889 by Mr. Giroux in his traverse of the St. Francis River. On this river, from a point three miles above Drummondville, near the falls, beds of the lower Trenton occupy the stream as far down as the fourth lot of the Augmentation of Wendover. From this point to lot sixteen of the same Augmentation, outcrops of gray, sandy shales and sandstones are seen, showing an anticlinal structure at two points in this distance. The dips, as a rule, are low, ranging from five to twenty degrees, and the gray beds, shortly below the sixteenth lot, become covered over by the red shales of the Medina (Silurian) already referred to. The lowest outcrop of Medina on the river is about four and a half miles above the village of Pierreville, below which no rock is seen to its junction with the St. Lawrence, the country being low and the surface consisting of clays.

The Yamaska River.

Ascending the Yamaska, no ledges are visible till within one mile and a half of the mouth of the Chibouet River, near the village of St. Hugues. Here beds of gray sandstone, with blackish and grayish shales, show in the stream. They contain an abundance of fossils, from which a collection was made by Mr. Giroux, as also from the beds on the St. Francis, just mentioned. At St. Hugues, the dip is S. E. $< 30^{\circ}$, and

the rocks extend thence along the river to opposite the St. Simon church, being exposed for about four miles. The stream flows very nearly along the strike. At St. Simon, where these rocks are blackish, crumbling shales with hard, sandy beds, the dip is S. 60° E. $<$ 70°. Thence up to St. Hyacinthe no rocks are seen.

St. Hyacinthe.

At St. Hyacinthe, the section exposed in the river, opposite the city, extends from just above the middle wooden bridge across the Yamaska to the dam or fall above the upper bridge. The rocks consist of grayish and greenish sandy, flaggy shales, some of which are finely micaceous, and have interstratified thin dolomitic bands.

Dykes of intrusive rock.

The sandy greenish beds contain graptolites, brachiapods and trilobites (see appendix), and are cut by dykes of greenish, moderately coarse doleritic or trappean rock, two of which cross the river and form rapids opposite the tanneries. The shales are much broken and altered along the contact. Several disturbances are seen in these rocks, and one well-defined anticline which occurs in contact with a dyke, soon becomes overturned. The general dip of the beds in this section is S. 60° to 70° E. $<$ 20°. Associated with the gray marly shales are occasional bands of hard flinty or cherty limestone, both blackish and brownish in colour. In the blackish beds Orthoceratites were found. Between St. Hyacinthe and St. Pie, which is on the East Branch of the Yamaska, ten miles distant, no ledges are seen; the water in the stream has no current, and the banks on both sides are mostly of clay.

St. Pie.

At St. Pie, a short distance below the road-bridge, ledges of black and bluish-gray limestone, with thin veins of calcite, cross the stream. These rocks are generally slaty and are cut by dykes of diorite, some of which are almost a pure crystalline hornblende-rock. One of them has a breadth of ten feet or more, and it has altered the limestone in contact by shattering and breaking the adjacent strata. In a band of slaty limestone, between the Canadian Pacific railway-bridge and the road-bridge, graptolites were found, with long, straight, single forms. No other fossils were observed by us, but from a collection made in 1879 by Mr. T. C. Weston, ten species were determined by Dr. Ami, which showed their horizon to be Trenton. (See appendix).

Fossils.

St. Pie and Abbottsford

Between St. Pie and Abbottsford, these black limestones frequently appear along the roads and in ledges through the fields. They are all highly cleaved, and though carefully examined for fossils, none other than those just mentioned were observed. These rocks continue eastward to the foot of Yamaska Mountain, where, at the west flank, they are found in contact with the eruptive rock of the

mountain mass, by which they have been greatly altered, the slaty limestone becoming very hard and cherty at the contact. Near the base of the mountain, certain beds of this limestone series have a conglomeritic character, with pebbles of limestone in a slaty calcareous paste. They are thrown into a series of folds, and are all highly cleaved. West of the mountain, they are exposed for nearly two miles, or to the level country, which continues thence to the Yamaska River. Diabase dykes are observed, sometimes nearly black in colour and generally fine-grained; and these usually occur along the bedding planes, but sometimes cut directly across the strata.

River des Hurons.

The country between St. Hyacinthe and the Richelieu River at Belœil, is flat, and no rocks are exposed till the rock of the mountain is reached. At several places along its base, ledges of sandy shales and limestones of Lorraine aspect are seen, and at the village of St. Jean Baptiste, on the River des Hurons, sandy and calcareous beds contain a great abundance of fossils. The locality was noted in the Geology of Canada (1863), p. 209, but large collections of fossils have since been made from this place, which present the usual Hudson River or Lorraine aspect. (See appendix). About St. Johns city, no rock-exposures are seen, but on the south-west flank of Mt. Johnston or Monnoir, about six miles north-east, blackish-gray limestone and slates were observed along the road in contact with the granite of the mountain mass, in which a layer containing fossils of Hudson River age occurs. These rocks are all highly altered along the contact. About Chambly Basin also, the Lorraine shales and sandstones are well exposed. These have yielded fossils, a good collection having been made from this locality in 1890 by Dr. Deeks, my assistant in that year.

Fossils.

Mt. Johnston.

Chambly Basin.

Utica shale near Montreal.

The Utica formation appears occasionally in the district east of the St. Lawrence, as well as about the Island of Montreal. Good exposures are found at Point St. Charles,* near the northern extremity of the Victoria Bridge, and vicinity, as well as at St. Helen's Island, already alluded to, and the characteristic shales of the formation appear again on the east side of the river above Longueuil, and thence toward Laprairie, beyond which place, to the south-east, this formation is concealed by the great mantle of clay and sand. At the village of Industry, or Joliette, on the west side of the St. Lawrence, the Chazy and Trenton beds are well exposed, but a small collection of Utica fossils in the Museum, made by Sir Wm. Logan in 1852, at this place, has been examined by Dr. Ami, and indicates the occurrence of an outcrop of this formation in the vicinity.†

Joliette.

*Geology of Canada, 1863, p. 207.

†Can. Rec. of Science, Oct., 1892, p. 21.—The Utica Terrain in Canada (H. M. Ami).

To the south and east of Montreal the Utica appears but rarely. Black shales with characteristic fossils show in the bed of the Little Montreal River at L'Acadie, west of St. Johns, and, further south, they are well exposed in the Lacolle River, half a mile east of Lacolle village. On the east side of the Richelieu, west of Clarenceville, on the road from Lacolle, black graphitic shales are exposed which contain graptolites and other fossils of a lower horizon. These are probably the equivalents of the Quebec city rocks, overlain by the Utica on either side. The typical Utica occurs again at Clarenceville and for some distance east towards Missisquoi Bay. The eastern area of the Memphremagog basin has yet shown no rocks of Utica age, the graptolitic shales there found belonging to a lower horizon, presumably the lower Trenton.

L'Acadie.

Lacolle.

Clarenceville.

The valley of the St. Lawrence, from Lake St. Louis almost to Quebec city, and for some miles on either side of the river, is occupied by strata of the Utica and Lorraine formations, between which, the line of separation at most points, is difficult to ascertain, owing to the great mantle of clay so widely distributed throughout this area. This region was one of the first studied by the Geological Survey. The strata exposed are nearly horizontal, disturbances being few and due to intrusive masses of doleritic matter. The rocks where exposed, abound in fossils, and their true horizons can therefore be readily determined. The doloritic rocks which intersect these strata, form mountain masses, sometimes of large extent, which present conspicuous features in the otherwise monotonously level landscape.

St. Lawrence River area.

These rocks, both the fossiliferous sediments and the intrusive masses, have been well described in the earlier reports of the Survey.* In the first of these, viz., that for 1847, the characters of the rocks visible on the line of section between Montreal and Lake Memphremagog are so clearly stated that but little remains to be said on that subject.

Intrusive mountains.

As, however, the relations of certain groups, more particularly the crystalline schists and the red and green slates and sandstones of the upper Cambrian (Sillery) were not at that time clearly understood, these will call for some remarks on a subsequent page. The general horizontality of the measures, except where this is disturbed by the presence of the intrusive masses or dykes, is maintained almost to the vicinity of the great St. Lawrence and Champlain fault, which, as already described in a former report, extends from the city of Quebec to the foot of Missisquoi Bay. The fault brings beds of the Trenton formation

St. Lawrence and Champlain fault.

*Report of Progress, Geol. Surv. Can., 1847-48, pp. 10-22. Report of Progress, Geol. Surv. Can., 1858, pp. 171-178, and Geology of Canada, 1863, pp. 205-210.

against the Calciferous and Chazy at Phillipsburg and Stanbridge, and its existence is very evident wherever rock-exposures are visible along its line; but as there is a heavy covering of drift over a considerable portion of the country which it traverses, its delineation on a map, between exposed points, must of necessity be largely conjectural.

Disturbances of strata.

This great fault marks one of the important geological features of the district under discussion, but the amount of displacement occasioned thereby is presumably no greater than that caused by other heavy faults which traverse the country in a north-east to south-west direction, and which are seen as far east as Lake Memphremagog. Not only is this entire area greatly affected by these faults, but extensive crumplings of strata have occurred, which have closely involved the rocks of the older or crystalline-schist series, with the most recent sediments of the district. Narrow areas of the Cambro-Silurian are seen, which contain fossils, but are apparently interstratified with the schists; while in some places the formations are so completely overturned that the fossiliferous Devonian now underlies the Cambro-Silurian.

Trenton formation.

The rocks of the Trenton formation, which underlie the Utica and Hudson River (Lorraine) just described, have also a wide distribution. In the earlier reports of the Geological Survey * certain portions of these rocks were included in the Upper Silurian; these comprise both the black graphitic limestones and associated clay-slates which have already been described,† and which will be more particularly discussed later.

St. Francis River, Drummondville.

The eastern limit of the most westerly area of these Trenton rocks, is seen on the St. Francis River about three miles above the village of Drummondville. They are here separated from another area of similar-looking rocks, presumbly of the same age, by a belt of greenish sandstones, with red and green slates of Sillery aspect. At Drummondville, the black slates and limestones contain graptolites, in character like those from the vicinity of Memphremagog Lake, and the rocks themselves are much broken up by intrusive masses of dioritic or trappean material.‡ From this locality a collection of fossils was made in 1863 by Mr. T. C. Weston which have been described by Dr. Ami (see appendix). Just below the rapids caused by the trap masses at Drummondville, the black slates dip nearly south $< 50°$, and in places are pebbly, some of the bands constituting a slate conglomerate. These

Fossils.

*Geology of Canada, 1863, p. 434.

†Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 16 J.

‡Geology of Canada, 1863, p. 718.

black slates are said by Mr. N. J. Giroux to extend for half a mile below the bridge at the town, and are generally much broken and jointed. On lot sixteen, range three, of Wendover, the black limestones, often slaty and occasionally sandy, are interstratified with brownish calcareous slates, and dip S. < 40° ; and a few miles below, or near the line between the townships of Upton and Grantham, a cliff about forty-five feet high, presents a good section of thin grayish or brownish-gray crumbling shales, which dip S. 25° E. < 60°. These contain thick bands of grayish-brown sandstone, the whole having the aspect of the Utica formation as seen at Montmorency Falls. These beds are somewhat disturbed, dipping generally at a high angle, both to the north and south, and they are probably affected by faults, indications of which are apparent at several points. They presumably represent a higher portion of the series than the blackish slate of Drummondville. Wendover. Faults.

To the north of this area, exposures of the fossiliferous rocks are next seen on the Becancour River, where, however, they are mostly confined to the Lorraine shales, and greenish-gray, sandy beds occupy the lower part of that stream for some miles, or to within a short distance of the road which crosses between ranges seven and eight of the township of Maddington. The lower exposures of these shales are nearly flat, but the dip suddenly rises to an angle of 60° to 70°, owing to sharp folding and faults. These grayish sandy beds, extend up the stream almost to the contact with the red and green slates of the Sillery, and the Trenton black limestones, if they occur at all, are reduced to a very limited area. Becancour River.

Returning to the St. Francis River, a second area of the black limestones, and associated blackish-gray calcareous slates, is seen in the stretch between the falls three miles above Drummondville and Richmond. The red slates and green sandstone of the Sillery, at the falls, are confined to a narrow band not more than one mile in width, and indications of faults are seen on either side. On the upper or southern side, the rocks in contact are a series of black limestones of lower Trenton aspect, resembling those of St. Dominique, which form the bed of the river for some distance. Thence up stream, outcrops of the same limestones are seen at several points, as far as lot eight, range one, L'Avenir, where these are underlain by the Cambrian slates of the area west of Richmond. St. Francis River Drummondville and Richmond.

The northern portion of the eastern area of these rocks, viz., that part north of the St. Francis River, has a very considerable development in the townships of Kingsey, Simpson and Warwick. The slates Kingsey.

and limestones can be traced continuously into the Warwick and Arthabaska district, described in a preceding report.* About French Village or Kingsey, the black limestones of this series are well developed, and the associated rocks are bluish-gray, often calcareous, and blackish-gray slates, the latter frequently containing pebbles of hard grayish-brown limestone or fine-grained sandstone. This pebbly character is well marked throughout certain portions of this entire formation and has served to distinguish the slates of this age, not only in the Wotton area, north of the St. Francis, but also about the shores of Memphremagog Lake, where also certain bands hold a great abundance of graptolites of presumably lower Trenton age.† The rocks of the Kingsey area are bounded on the west, at several points, by red slates and hard green sandstones of upper Sillery (Cambrian) aspect, although owing to the great covering of drift which prevails at many places, the continuous contact cannot be observed. In some places this is doubtless of the nature of an overlap, while at others the structure is complicated by faults.

Fossils.

Richmond.

On the line of the Grand Trunk railway, between Richmond and Actonvale, these rocks were also seen at several points. At Richmond, another basin which extends along the line of the Grand Trunk to Danville, has been already described in my report of 1886.‡ This crosses the St. Francis into Melbourne and thence continues south in a rapidly narrowing valley, extending up the stream which flows from Brompton Lake past the village of Kingsbury, near which place is the celebrated New Rockland slate quarry. To the south of Kingsbury, the peculiar graphitic limestone and shales, by which the formation is easily recognized, can be traced in a very narrow outcrop for several miles along the road to Melbourne Ridge, in which direction it separates the crystalline pre-Cambrian schists from the red and green or bluish-gray slates and quartzites of the Cambrian. On the Grand Trunk section, after passing the green chloritic rocks, (which are, to some extent at least, schistose diorites, and which form an almost continuous band from the Vermont boundary all along the flank of the mica-schist series of the central anticline), a series of black and gray wrinkled, often woody-fibred slates, is found, cut by quartzose veins and containing, in their upper parts, beds of hard quartzose sandstone. These are well exposed about South Durham and Lisgar stations, where they rest directly upon the green chloritic rocks just mentioned. Several purple bands occur in the lower part, and these are well seen along the St.

Grand Trunk railway, Richmond to Acton.

* Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 19-20 J.

† Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 16 J.

‡ Annual Report, Geol. Surv. Can., 1886, vol. II. (N. S.), p. 18 J.

Francis River, where they have been opened for a slate quarry, which was subsequently abandoned. About two miles west of the station of South Durham, ledges of hard sandstones resembling the Sillery, are overlain by black and bluish-gray calcareous slates, with beds of black limestone, like the rocks seen in the St. Francis River section. The latter show the presence of foldings, but generally they dip at moderately low angles of from twenty to forty degrees. These are seen in cuttings between Durham and Danby, but beyond the latter station the surface falls easily to the crossing of the Moose River, beyond which, towards Actonvale, the red slates and sandstones of the Sillery are again exposed.

Sillery red slates, &c.

Black ates and limestone.

Tracing the black calcareous slates and limestones southward, their western limit in this direction is seen at the crossing of the Moose River on lot thirteen, on the road between ranges three and four, Acton, where bluish-gray, calcareous slates dip S. 70° E. < 75°. Thence they are exposed along the road to South Durham for about three miles, to the point where this road meets the railway, two miles west of Durham station, being here terminated by the underlying sandstones of the Sillery. Further to the south, they are found near Bethel, or North Ely village, at which place also fossils have been found in the limestones, associated with these slates, precisely similar to those obtained from the beds of Danville and Richmond. Further to the south-west, these rocks apparently abut against the mass of Shefford Mountain, on the north side of which dark limestone and bluish-gray calcareous slates are seen; and, in the valley lying between the Granby ridge and West Shefford, there is a second development of the bluish-gray, pebbly slates, with which, on range three, lots five and six, Granby, small outcrops of the black graphitic limestone are found.

Acton.

Durham.

North Ely.

Fossils.

Shefford.

In the townships of East and West Farnham, these rocks assume a greater breadth. They rest unconformably upon the series of red and green shales and green sandstones of the Granby ridge, which terminates in this direction before reaching the north branch of the Yamaska. About the village of Adamsville, the black and bluish-gray pebbly slates are well exposed, but are too highly cleaved to disclose the presence of fossils. A short distance to the south-west, on the south branch of the Yamaska at Brigham post-office, a considerable exposure of black limestone is seen on lots twenty-four and twenty-five, range two, East Farnham. The limestones are generally slaty and cleaved, but in some places there is a dip S. 85° E. < 20°. They strongly resemble the beds of St. Dominique, East Farnham and Danville in aspect, and are exposed in the stream for about 500 paces

Farnham.

Adamsville.

Fossils.

below the road. They contain traces of graptolites and are cut by quartz-veins. No other fossils were observed at this place, but, in the river below or near West Farnham, blocks of considerable size were seen, probably from the same series of beds, which contained a great number of fossil forms, all of which appear to belong to the Trenton formation. The position of these calcareous slates and slaty limestones, is apparently below the bluish-gray pebbly slates, and, if we take a line of section from the fault at Farnham, south-east to Cowansville and Sweetsburg, the structure of these rocks, which have been the subject of dispute for some years, will be made clear.

Farnham to Cowansville.

At Farnham, in the bed of the Yamaska River, there is a very considerable exposure of calcareous rocks, including slates and limestones. Beginning with the lowest of these, about three-eighths of a mile below the road-bridge, grayish-brown, somewhat micaceous, sandy slates are seen, dip N. 85° E. $<$ 20°. Below this the river is filled with large boulders, the country is flat, and no ledges were observed. These slates are cut by dykes of coarse hornblendic diorite, in places made up almost entirely of hornblende crystals, the dykes ranging in width from one to ten feet or more. While these generally follow the lines of bedding they sometimes cut directly across them. Approaching the highway-bridge in the centre of the town, the rocks become darker and more calcareous, with beds of dark grey or black limestone, which are rusty on weathered surface and are evidently dolomitic. These bands are associated with slates, which are much twisted and cleaved across the bedding. Between the two railway bridges, traces of graptolites are seen, and in certain black slaty beds a hundred yards above the upper railway-bridge, interstratified with the black limestone, an *Orthoceras* and several other fossils were obtained. In the extension of these beds on the south side of the river, graptolites were found, all straight forms, the rock breaking out in broad flaggy pieces which are cut by diorite dykes as at St. Pie. Most of these beds are also cleaved across the bedding and the fossils are hard to obtain. In a thin band which accompanies the graptolitic slates, *Ptilodictya* and crinoid stems were seen, with several other forms not determinable. Thence up stream for nearly two miles, the black slates and limestones were observed, in the upper part becoming greatly broken and altered, some of the beds being cherty and hard like those at the Marsouin River on the St. Lawrence, traces of graptolites being also seen in these. This is presumably not far from the line of fault between the Trenton beds and the Sillery of the Abbottsford and Granby area; the actual contact here being concealed by drift, though pieces of the green and red slates are plentiful in the stream.

Intrusive dykes at Farnham.

Fossils.

Cherty beds.

On the road from Farnham to Cowansville, which follows the river-flat for some distance, rock-exposures are few for the first four miles, only one ledge of the black cherty slates being visible, about one and a half mile east of the first-named town. Red and green slates occur in the river on lot thirty-three, range three ; while a knoll of hard grayish-green sandstone on lots thirty-one and thirty-two, range three, of West Farnham, probably marks the southern extension of the Sillery ridge, south-west from the town of Granby. These rocks do not come quite to the railway-crossing on the road, and on the east side, on lot thirty, range three, they are succeeded by the series of blackish and grayish pebbly slates, which occupy the valley south-east of Granby, already described. These are seen at intervals along the road to Farnham Centre, near which place, on lot twenty-six, range one, Farnham, the ledge of black slates and limestone occurs as described in the Geology of Canada, 1863 (p. 239). The fossils from this place as there described have a manifestly lower Trenton aspect. (See appendix).

Road east of Farnham.

Farnham Centre fossils.

The exposure already referred to, on the branch of the Yamaska, is to the north-east of this locality and on the strike of the beds just mentioned. On the road leading to Brigham from Farnham Centre, ledges of the thin bluish-gray slates of the Adamsville area occur. A list of fossils from this locality is given in the appendix.

Brigham.

From Brigham post-office to Allan's Corners, the country is generally level and covered by sandy drift; but on the roads to the north and south occasional outcrops of the bluish-grey pebbly slates are exposed. These are highly cleaved and the dip is doubtful, but they appear to be thrown into a series of folds. Just south of Allan's Corners or East Farnham, on the road to Cowansville, bluish-gray dolomitic slates, with small masses of limestone, occur, which contain fossils. These rocks are precisely similar in character to the Chazy slates seen at Mystic, from which large collections of fossils were made in previous seasons, and the contained masses of limestone near Allan's Corners are also fossiliferous in the same way as those in the strata at Mystic. These dolomitic brownish-weathering slates extend through Cowansville, and are exposed on the road east from East Farnham, to the intrusive mass of Brome Mountain. At several points they contain limestone bands which yield fossils, such as to show them to be the equivalents of the Mystic limestone and slates.

Allan's Corners fossils.

It would therefore appear that the black limestones and slates of Farnham Centre, occupy the centre of a synclinal in Chazy rocks, the western outcrops of which are seen along the road from Farnham south to Mystic, while the eastern is seen on the roads west of Cowansville ;

Syncline in Chazy.

and as the contained fossils are of lower Trenton aspect, the apparent stratigraphical position is clearly supported by the palæontology of the section.

L'Ange Gardien.

To the north of Farnham, (Farnham station) the road to L'Ange Gardien and Abbottsford shows ledges of blackish-gray slates and limestones similar to those just described as occurring about the former place. On the road east from L'Ange Gardien, these black limestones are exposed for nearly one mile and three-fourths, the probable contact with the red and green shales of the Sillery being 1140 paces beyond the angle of the road, east of the village. This is on the St. George range road. The actual contact is here concealed by a low swampy flat. Dykes of diabase rock, apparently from Yamaska Mountain, cut the red and green slates of L'Ange Gardien as well as the black limestones of that locality.

Papineau range road fossils.

On the Papineau range road, two miles south of Abbottsford, the line between the Trenton and the red slates crosses about one mile and a half east of the Farnham road, in a valley near a small brook, the red slates showing on the east of the brook, and the black limestones on the west, just beyond the line of the Canadian Pacific railway. At this locality, the most extensive outcrops are about one-eighth of a mile west of the railway and about the same distance north of the Papineau road. They consist for the most part of dark, grayish-black, or black, slaty limestone, which in places contain graphitic layers. Crinoid stems were seen in some of the beds, and loose pieces contained a great abundance of Trenton forms; but these were not found in place. Bands of limestone conglomerate, with partings of dark or blackish-gray shale occur as a part of the series, and contain large pebbles of grayish (dove-gray) limestone, which hold whorled shells; both the pebbles and the contained shells being precisely similar to what are found in the eastern portion of the Phillipsburg section where the rocks are of Chazy age. The rock, as a whole, resembles somewhat the Stanbridge conglomerate, but the pebbles are not so numerous. These limestones have been burned quite extensively for lime, but the quality is not considered so good as that produced from the stone of St. Dominique. East of the main area of the dark limestones, which are all highly cleaved, on the Papineau range road, there is a considerable thickness of grayish and bluish-gray slates, in places somewhat dolomitic, which extend nearly to the railway. These rocks resemble very strongly those on the Grand Trunk railway between Durham and Danby. They do not at all resemble the rocks of the Utica or Lorraine in character, and are, in so far as examined, devoid of fossil remains.

Contact of Trenton and Sillery.

Between L'Ange Gardien and the Papineau range road, on the road from Farnham to Abbottsford, black limestones show for several miles south of the latter place; but approaching L'Ange Gardien, splintery grayish clay-slates, like those of St. Liboire, on the Grand Trunk railway, east of St. Hyacinthe, occur at several places. These are apparently an upper portion of the black limestone series, and probably the equivalent of those seen at Farnham, in the lower part of the section on the Yamaska River. They also show along the road south of L'Ange Gardien, with pebbles in places, and resemble both the rocks east of Granby, and those near Memphremagog Lake, presently to be described.

West of Yamaska Mountain, at Abbottsford, the strata are mostly black calcareous slates and blackish limestones which weather in places to a shade of brown. They extend to the flank of the mountain, where their contact with the eruptive rocks has already been described. Abbottsford.

Although well exposed for two miles or more west of the mountain, in the fields and on the several roads, a search for fossils in these beds was unsuccessful. They have generally a dip to the south-east at angles of 20° to 40°, but are highly cleaved. That they are the extension of the beds seen at St. Pie and St. Dominique is apparent from their position and general aspect; and probably a more exhaustive search in beds unaffected by cleavage, if such can be found, would result in finding fossils similar to those obtained at those places.

The section at St. Dominique, further north, has already been described in the Geology of Canada.* The exposures here rise quite abruptly from the generally level country which extends thence to St. Hyacinthe, and the lowest beds seen are grayish nodular limestones, which are extensively quarried for building stone. The limestone beds have thin partings of black shale, and both contain fossils which show them to belong to the upper part of the Chazy formation. Ascending the hill, which is about fifty feet high, these Chazy beds gradually pass into the series of blackish limestones and calcareous slates, which we have just been describing, and which should therefore represent the Black River formation. Certain bands in these are highly fossiliferous, but, as a rule, all the beds of this series are affected by cleavage planes and the fossils are difficult of extraction. The beds at the lower quarry, dip S. 80° E. $<$ 20° to 30°, and at the quarry at the top of the hill, S. 70° E. $<$ 20°. The colour of the limestone at the top of the rise, is a dark lead-blue, and the beds are frequently cut by veins of calcite. These strata contain fossils of lower

St. Dominique. Fossils.

*Report of Progress, Geol. Surv. Can., 1847-48, p. 18; Geology of Canada, 1863, p. 205.

Trenton age. To the east of these exposures the limestone becomes more slaty, and is frequently black and highly cleaved in the direction of the dip, at an angle of 70°. Certain beds hold *Trinucleus* in abundance, but, owing to the cleavage planes, it is difficult here also to break out good specimens. These beds become more shaly in the direction o the St. Dominique church, and contain bands of hard dolomitic limestone, resembling in general aspect, the rocks of the city of Quebec. Fossils were not found in the upper part of the section, which terminates just before reaching the church, but this probably represents some portion of the Trenton series.

Fault.

Going east from St. Dominique, the road descends very gradually to the low plain of the Black River, and shows no ledges in so far as examined; but on the roads to the south, towards St. Pie, brownish-weathering black slates like those of that village, are seen at intervals. These are terminated about one mile and a half before reaching the Black River, by ridges of hard greenish-gray Sillery sandstone, the fault between the two series evidently extending from about midway on the north side of Yamaska Mountain and keeping to the west of the stream mentioned. North of the village of Upton, this fault crosses the road about three miles north of the Grand Trunk railway, just to the west of the knoll on which the Upton copper mines are situated, whence it apparently extends to the falls of the St. Francis, three miles above Drummondville, where the contact with the red Sillery slates has already been described.

Phillipsburg and vicinity.

The section of these rocks, south of Farnham, is a very important one, and throws much light upon some intricate points of structure in connection with the fossiliferous Quebec group, as stated in the Geology of Canada, more particularly as regards the peculiar rocks of Phillipsburg, Bedford and North Stanbridge. This area, beginning at Phillipsburg and extending eastward through St. Armand, and south to Highgate Springs, Swanton and St. Albans, has long been historic. The structure is complicated by faults, some of which are apparently of considerable extent and in places the beds are overturned. The opinions of various geologists concerning the age of these rocks have been already very fully given by several writers in the United States, in connection with the discussions of the Taconic controversy, which presents some features closely resembling those which pertain to the Quebec group question in Canada. The bibliography of the subject will be found in the "American Geologist," for February, 1889, in a paper by Prof. Jules Marcou, entitled "Barrande and the Taconic System," as well as in papers by Mr. C. D. Walcott.

The description of the rocks of this area, and the early views as to their structure, are well given in preceding reports on the part of the Geological Survey.* Further data bearing on the subject, as well as a brief abstract of the discussion on this question, were given in the Annual report for 1887-88, pp. 39 K-40 K, so that it is necessary, in the present Report, to state merely the final conclusions arrived at as regards their actual structure, in so far as this has now been ascertained.

Peculiar character of rocks and fossils of the Phillipsburg series.

Before discussing the problem of the Phillipsburg rocks, it may be well to state that, while strata containing fossils of Calciferous and Chazy aspect are found at several points along the road section between Phillipsburg village and St. Armand station on the Central Vermont railway, the character of the beds is different from what is found in the regularly stratified series of the typical Calciferous and Chazy of the Ottawa valley. The fossils also, while presenting characters seen in these formations, can not, in most cases, be identified with those found so abundantly in the typical Calciferous and Chazy areas. Thus, in the Ottawa section, where the strata are undisturbed and nearly flat, the lowest beds of the Chazy, directly overlying the dolomitic beds of the Calciferous, are greenish grits and sandstones, which gradually become shaly and calcareous, so that there is a very considerable development of the sandy beds in the lower part of the Chazy before the Chazy limestone is reached. Certain shaly beds of the lower Chazy contain fossils, but the greatest development of fossiliferous rocks is in the upper, or limestone portion. In the Phillipsburg section, there is no trace of the sandy or shaly greenish-gray lower portion of the Chazy formation as developed further west; the limestone, regarded as Chazy, succeeding directly upon those beds which have been referred to the Calciferous, from the evidence of the fossils. This difference may be explained either on the assumption that a fault has cut out the lower or slaty portion of the Chazy, (of which however there does not appear to be any very clear evidence), or, on the ground that the conditions of deposition in this section, east of the St. Lawrence, have been entirely different from those which prevailed to the west of that river; so that, instead of littoral deposits, resulting in shales, grits and sandstones, as found in the typical Chazy of the Ottawa district, the deposition was for the most part in deep water, and the sediments laid down were almost entirely calcareous. In the latter event it would be exceedingly difficult, as is indeed the case, to draw any sharp line of division between the Calciferous and Chazy formations for the eastern area.

*Geology of Canada, 1863, pp. 273-287 and 844-862.

The rocks on the shore of Missisquoi Bay, at Phillipsburg, west of the fault, are blackish-gray and black slates with bands and lumps of dolomite, in certain beds of which, graptolites are found. The exact horizon of these can scarcely be determined from the fossils obtained, but from their general appearance they would seem to belong to the Trenton (probably lower) series, and they have been so described. They would therefore probably represent the extension southward of the beds described as occurring at St. Pie and Abbottsford, which are separated, by the great St. Lawrence and Champlain fault from the Sillery rocks of Abbottsford, from the Chazy of Stanbridge and the Calciferous of Phillipsburg, a short distance further south. These beds are also continuous across the boundary into Vermont, and their extension into that state has been described under the head of Trenton-Utica, at Highgate Springs.*

Fossils.

Trenton west of fault.

Area East of the St. Lawrence and Champlain Fault.

Fault at Phillipsburg

At Phillipsburg village, where the contact between these rocks and those of the Phillipsburg series proper is well seen, the fault is clearly defined, the slates along the contact being broken up, and clearly showing the effects of the dislocation. Eastward of the fault, the grayish, calcareous beds described on page 844 of the Geology of Canada (under Division A) come in. These extend to the valley in which Strites' Pond is situated, and, according to the measurement of Sir Wm. Logan, this portion has a thickness of 700 feet. In the section just quoted† the rocks of Division B, aggregating 1040 feet, represent the middle and upper portion of the Calciferous, and shade gradually into the Chazy in the upper part, so that the point at which the exact line of division between the two formations occurs is scarcely indicated.

Thickness of the Calciferous.

Chazy syncline near St. Armand Station.

The Chazy, or upper portion, occupies a well defined syncline in the eastern part of the section, the centre of which is seen on the road from Phillipsburg to St. Armand station, on the Central Vermont railway, near the beginning of the steep descent to the valley of Rock River, and fifteen chains west of the railway itself. Looking south-west from this point, the extension of this syncline is seen about three-fourths of a mile distant, the north-west dip being well exposed on the road in lot twelve, west St. Armand, and in outcrops along the west side of the railway, about half a mile south-west of the St. Armand station. These rocks carry an abundance of fossils, of which large collections were made during the season of 1890.

*Geology of Canada, 1863, pp. 854, 855.

†Geology of Canada, 1863, p. 844.

They resemble in characters those of the Calciferous and Chazy formations. Many very perfect specimens were also obtained from this section some thirty years ago by Logan, Billings, Whiteaves and others.

On the road going north from St. Armand station, this synclinal structure is also well seen, and the apparent line between the Calciferous and Chazy in this direction is about sixty chains south of Blood's Corners, which is the old name of the cross-roads in lot one, range nine of Stanbridge. As nearly as can be ascertained, the line between the two formations, the Calciferous and Chazy, as seen on the road from Phillipsburg, may be placed near the sharp bend seventy chains west of the cross-road at St. Armand station, (formerly Moore's Corners). The rocks of the Calciferous formation between this point and the village of Phillipsburg extend in several ridges to the north-east and south-west. In the former direction they appear to end, through faulting and by the overlap of the Chazy beds, about three-fourths of a mile north-east from Blood's Corners. In this direction they keep close alongside the road going from Blood's Corners to Stanbridge station, as far as the sharp bend in the road on lot two, range nine, Stanbridge, the blackish slates of the Trenton being in contact on the west side all the way. On the road east from Blood's Corners they are apparently overlapped by the Chazy, twenty chains west of the crossing of the Central Vermont railway, the Chazy at this place being affected by slight undulations in the centre of a somewhat broad synclinal basin which occurs in these rocks in this direction. Beyond this, to the north, the Calciferous beds are not seen, while those of the Chazy, comprising limestone, limestone-conglomerate and slates, are well developed, and the strata are in places very rich in fossils, more particularly in the more northerly portion of the belt, about two miles north of Mystic (formerly Stanbridge Centre). From these beds also large collections have been obtained. (See appendix.)

St. Armand north.

To the south-west of Phillipsburg, the Calciferous rocks extend along the shore of the bay, separated from it for nearly a mile by a very thin margin of the black, calcareous slates of the Trenton. On the boundary-line between Quebec and Vermont, the centre of the Chazy syncline is seen about one mile and a quarter from the shore of the bay and the rocks of this series have been traced but a short distance south of the line in this direction.

St. Armand south.

The structure of the two principal synclines which occur along the Vermont boundary between the Sutton Mountain axis and the shore

Two synclines.

of Missisquoi Bay (more particularly seen between Phillipsburg and St. Armand, and further east between that point and Frelighsburg) is basin-shaped to the south, so that the lower rocks converge towards the boundary. The newest rocks of the section do not, therefore, extend so far south, the centre of the syncline having a declination north-east at a low angle.

Stanbridge and Bedford.

The Chazy fossiliferous rocks which occupy the syncline in the Calciferous of Phillipsburg extend continuously from the Vermont boundary in a north-east direction to lot twenty-two, range six, Stanbridge. They consist, as just stated, of limestones, limestone-conglomerates and slates, bluish-gray and frequently dolomitic as evidenced by their rusty-brown weathering. They are affected by folds, several anticlines being visible. Their most westerly observed outcrop is on the road from Stanbridge station to Bedford, and on the road parallel to this on lot six, range eight, Stanbridge. On the former road, ridges of conglomerate cross the highway and extend nearly to the bank of the Pike River. This is one mile west of Bedford Corners. The rocks here dip about S. 75° E., at a moderately low angle; but on the road south of this, at what is marked on the map in the atlas of 1866 "Mr. Carey's place," the first outcrops near the line of railway, dip N. 55° E. < 55°, which dip, however, rapidly changes in going east, to N. 15° E. < 2° to 5°, and on the road thence north to Bedford, on range seven, is reversed to north-west, showing the presence of a low and broad sycline in this direction. The south-easterly dip of the western line of outcrop, is maintained to the extreme northerly exposure. Thus near Wallbridge's mill, at Mystic station, the dip of the conglomerates and associated dolomitic slates is S. 50° E. < 30°, while at the most northerly outcrop on lot twenty-two, range six, it is S. 40° E. < 25°.

Mystic Station.

The most easterly outcrop of the Chazy conglomerates, is on lot twenty-two, range five, where the dip also is S. 40° E. < 60, and the entire breadth across the measures at this place is eighty chains, which, if there were no folding of the strata, and assuming the dip to be 25°, (apparently to be the average from most of the outcrops in this section,) would give a thickness of something over 2000 feet for this portion of the Chazy. It is possible, however, that this area may be affected by foldings which do not appear at the surface, but the apparent structure at this place is, as stated, that of a broad syncline. Throughout these outcrops, fossils are abundant, and can be obtained both from the pebbles and the paste. Many of the pebbles show that they are derived from the Calciferous beds of the Phillipsburg and St. Armand section, while the fossils from the paste indicate that the rocks themselves are probably the equivalents of the Chazy. An inter-

Thickness of the Chazy at Stanbridge.

esting discovery during the past season, was the finding of graptolites in bands of dark gray limestone with dolomitic slates on lot nineteen, range six, Stanbridge, in a small outcropping ledge about twenty chains north of the road leading to North Stanbridge.

The Chazy rocks of Bedford and vicinity have been very fully described in the Geology of Canada (pp. 849-850.) East of St. Armand station, the area is divided by the prominent ridge of the Georgia sand-rock, described in the report just quoted under the heading of Potsdam, but which the recent observations of Mr. C. D. Walcott have shown to be much lower in the scale than the Potsdam sandstone of Canada. There is no error, however, in the determination of Billings and Logan as given in the Geology of Canada, since at that time (1863) the term Potsdam, in Canadian geology, was employed to include all between the Calciferous and the Huronian. Lower Cambrian of St. Armand.

Mr. Walcott has, however, succeeded in finding a very considerable fauna, of trilobites particularly, in the extension of these rocks southwards, which enables them to be more accurately placed and they appear now to be assignable to a horizon lower than Potsdam and probably in a great part to the Lower Cambrian.

The area of these rocks to the north of Vermont is small. They extend north in a band of about a mile in width as far as the forks of the road, on lot 131, West St. Armand. They are directly overlain on the west by the limestone-conglomerate just described, which dips near the contact south-easterly at angles of 5° to 10° and this apparently folds over the low ridge of the older rock. At the direct contact on the north-east extremity, however, there are indications of a fault, in the broken character and highly tilted position of the Chazy limestones and slates, the dip being both to the north-west and south-east < 90° to 75°, but diminishing in a short distance from the contact itself to 20°. Georgia sand-rock. Fault.

On the road going north from the terminus of this Cambrian outcrop on ranges six and seven, ledges of limestone-conglomerate occur at intervals, with the usual dolomitic slates. By their change of dip, they show the presence of foldings at several places, so that it is impossible to ascertain the thickness of the measures in this direction. The areas of limestone-conglomerate are, however, not numerous, and they do not, in so far as yet known, appear east of the branch of Pike River in range six.

The eastern limit of the Cambrian (Georgia sand-rock), is seen on the road east from St. Armand to Frelighsburg, at the cross-road on lot 126. Beyond this, to St. Armand Centre, a series of outcrops of bluish- Pebbly Trenton slates.

gray slates occurs, which are calcareous in places and dolomitic-weathering. At times these contain pebbles like the strata seen east of Granby and on the west side of Sargent's Bay on Memphremagog Lake, as well as at other points already referred to. While several low undulations are apparent, their general structure is that of a syncline sloping towards the north-east. The beds of black limestone and slate of Farnham, which there come in upon the dolomitic slates, do not anywhere appear in the vicinity of the Vermont boundary, at least in so far as yet observed by us.

Northern Vermont.

The extension of this area into Vermont, can be traced on the road leading from Highgate Springs to Highgate Falls. After crossing the ridge of the Cambrian, or red sand-rock, to the east, the rocks first seen are the bluish-gray, dolomitic slates, precisely like those observed on the road from St. Armand to Pigeon Hill and in the vicinity of Mystic. Their contact with the Cambrian is a short distance west of the village of Highgate Falls, and these slates have, in Vermont, yielded, to Mr. Walcott, fossils of Chazy age. Just at the bridge at Highgate Falls, they are apparently cut off by a great overthrust fault, which brings up the Cambrian again upon the Chazy. Going south from this place about half a mile, at Hungerford Brook, ledges of blackish slates, calcareous in places, form an anticline at the bridge over the highway. These slates have yielded fossils of Cambrian age. A fourth of a mile south of this brook, ledges of limestone and limestone-conglomerate, in places a breccia, occur along the road, associated with great exposures of brown-weathering dolomite which are cut by small veins of quartz. The conglomerates or breccias contain masses of limestone which hold fossils of Upper Cambrian age, such as *Agnostus Orion*, &c., so that the horizon of the dolomites themselves is apparently the same as that of the associated fossiliferous slates, and they here form the western side of the Chazy syncline.

Limestone conglomerate.

Fossils.

Sweetsburg.

The position and age of the prominent dolomite bands of this locality are important questions, as they assist in the mapping out of the structure north of the Vermont boundary. They are the precise equivalents, in aspect and associated strata, of the heavy dolomitic bands which cross into Canada about two miles south-west of St. Armand Centre, near West Franklin. They cross the Boundary on the east side of the syncline, near the line between lots fifty-six and sixty-seven, west St. Armand. Here they directly underlie, on the east, the series of Chazy slates (dolomitic) already described, and extend thence in a north-east direction past the village of St. Armand Centre to Lagrange's Mill. Thence northwardly they skirt the west side of the village of Dunham. Further to the north-east they form a

prominent ridge, south of Sweetsburg, whence they continue to the south-west corner of the Brome Mountain. The dolomite bands are well exposed on the road leading north of Sweetsburg, and the associated slates are well-banded and very greatly disturbed.

These bands of dolomite, which are a prominent feature in this district, serve to define very clearly the eastern limit of the Chazy or Cambro-Silurian strata in this direction. Dolomite bands.

Memphremagog Lake Area.

The most easterly area of the Cambro-Silurian rocks included in the south-west quarter-sheet map, is that about Memphremagog Lake. They here form the extension to the south-west of the great series of south-eastern Quebec described in the Annual Report of 1886.* They are there said to occur in two distinct areas, of which the western is situated to the west of the Sherbrooke anticline, and occupies the townships of Wotton, Brompton, &c., while the eastern occupies the great portion of the country east of the Sherbrooke anticline, and has in part been styled by Hitchcock, in his report on the geology of New Hampshire, the Calciferous mica-schist series. The rocks of the two areas differ somewhat, more particularly in the development of limestone, the eastern area, in certain portions, being largely a calcareous formation, while in the St. Francis River area, the limestones are comparatively rare, and the slates are the prevailing rock. Memphemagog Lake area.

The age of these limestones, was ascertained not only by the presence of fossils at a number of points in the limestone itself, but by the occurrence of graptolites in the slates with which they are in some places associated, and which stratigraphically appear to form the lower part of the series. While these slates and limestones are presumably of the same age as those already described as occurring in the Granby and Farnham section, and their extension north to Kingsey, the character or aspect of the calcareous portion of the series is somewhat different, owing presumably to the great alteration which has affected the rocks of the central and eastern areas. Thus they have frequently become graphitic, and in places, more particularly near the granitic areas, have had a schistose structure imparted to them, with the addition of mica and staurolite crystals. Fossils. Lower Trenton. Black slates and limestone.

The two areas about Memphremagog Lake, are separated by the Cambrian and pre-Cambrian ridges which extend south-west from Massawippi Lake to Memphremagog Lake. The rocks of the more

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), pp. 15 J, 21 J.

Pebbly black and gray slates.

northern portion, consist of blackish-gray and bluish-gray slates, frequently thickly studded with ochreous spots, which are principally caused by the decomposition of crystals of dolomite. These slates often become almost a conglomerate, through the presence of scattered pebbles of hard sandstone or even of limestone, and have been elsewhere referred to under the name of pebbly slates. This pebbly character is well seen on the south-west side of Memphremagog Lake, both near the contact with the Silurian, where the graptolitic bands are developed, and further west, about the flanks of Orford Mountain; also along the roads leading south through Bolton and Potton townships, at a number of points east of the Cambrian of the Missisquoi Valley. These rocks are precisely similar in character to those noted in 1886 in Wotton township, to the north of St. Francis River, which were formerly regarded as Silurian.

Graptolites of Castle Brook.

The graptolites obtained in 1886 have already been described,* and clearly show the horizon of these rocks. Since then a new locality on Castle Brook, lot five, range fifteen, Magog, has been discovered, which is probably the most productive in graptolites of any yet found in Canada, and from which large collections have been made, both by ourselves and by Mr. Walcott of the United States Geological Survey. The graptolitic slates are best seen at Willard's mill, where their surfaces are completely covered with beautifully preserved forms. About ten species of graptolites have been recognized by Dr. Ami from collections made at this place. The rocks of this division, which occur east of Memphremagog Lake and west of the Cambrian of the Fitch Bay ridge, do not show limestone in any quantity. They consist for the most part of slates, often with scattered pebbles and frequently with ochre-spotted beds, while certain bands are highly graphitized, and contain graptolites, which, although poorly preserved, are similar in character to those from the west side of the lake. Thsee are on lot nineteen, range two, Stanstead. The same graphitic band of slates, is seen in its extension to the north-east on the road crossing lot twenty-three, range three of the same township. Near the line between lots sixteen and seventeen, range two, a band of conglomerate, with pebbles of slate, sandstone and quartz, crosses the road just beyond the brook, and probably marks the lower part of the Cambro-Silurian in this direction, since, on the ascent of the hill to the south, black and green slates and hard sandstones of Cambrian aspect occur.

Conglomerates.

Graptolitic slates.

In many places around the shore of the lake and at points inland, traces of these graptolites are found, though their perfect preservation

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 16 J.

is rare, owing apparently to the very considerable degree of metamorphism which has affected all the strata in the vicinity. The strata are often broken up and are cut by intrusions of different kinds of trappean or volcanic rock, some of which are white and felspathic, while others are a green diabase. These vary in thickness from dykes of two feet or so, to great masses, and it is clear that the smaller dykes seen about the shores of the lake are, in some cases at least, spurs from some one of the larger masses forming hills; precisely as the dykes which cut the strata about Yamaska and the other mountains of that district are connected with and can be traced into the intrusive masses there. That the mountain masses of Orford, Hog's Back, Sugar Loaf and Owl's Head, with, a number of lesser hills to the west of Memphremagog Lake, are intrusive in the slates of that area, is shown by the broken character of the slates in contact, in their great alteration near these contacts, evidenced both by a porcellanizing or other hardening of the strata, in some places, and by the formation of crystals through the mass of the slates at many points.

Intrusive masses of Memphremagog Lake.

The intrusive character of the dioritic matter, is also seen in the fact that many of the dykes cut directly across the stratification of the slates themselves. That the whole series has been profoundly disturbed since the deposition of the Silurian, is very clear, since all the strata (viz., the Cambro-Silurian, Silurian and Lower Devonian) are inclined at high angles and in some places inverted, as in the case of the Devonian limestone at Owl's Head which dips directly beneath the Cambro-Silurian slates, only a short distance from where the latter are seen to be acted upon and penetrated by the great mass of the Owl's Head Mountain. The fossiliferous Silurian beds of Round Island, a short distance south of Owl's Head, are moreover penetrated by great dykes of green diabase similar in character to the rock of the mountain, and on the east side of the lake at Capt. Gully's Cove, the presence of large dykes, both of green diabase and green, soft, talcose-looking matter, which have broken directly through the fossiliferous sediments and altered them along the contacts, is readily observed.

Their action upon the slates.

The Cambro-Silurian rocks south and east of Fitch Bay, which is an arm of Memphremagog Lake on the east, differ, as already stated, in some respects from the slates of the lake itself. These slates are largely calcareous near their western outcrop, which closely follows the east shore of the lake south of Fitch Bay and the south shore of the bay itself to its head, running thence along a depression to the north-east to Massawippi Lake, where, about the south end, they are well seen in large cliffs along the highroad and on the east side of the lake

Fitch Bay

Massawippi Lake.

in the numerous cuttings of the Boston and Maine railway (formerly the Passumpsic railway), from Sherbrooke to Newport.

Black slates and limestones of Stanstead.

On the section going south-east from Fitch Bay Narrows, through Smith's Mills to Stanstead, the relations of the limestones and the black pebbly and ochre-spotted slates are well seen. The first rocks, after passing the bridge and ascending the hill to the south, are bluish-gray and blackish graphitic limestones with slates, which dip N. 50° W. < 45°. These are the same in character with the rocks of Massawippi and North Hatley. Going south, similar rocks were seen to the line between lots five and six, range five, where the granite is met. This forms a knoll on the west side of the road, and is generally gray in colour, composed of white felspar, black mica and gray quartz, the rock being generally coarse in texture.

Action of the granite on the slates and limestones.

The granite extends from this place to the Vermont boundary, and on the east shore of the lake, its contact with the limestone is observed near the line between lots three and four, range three. Near Beebe Plain or Stanstead Junction, the contact of the granite and limestone is seen in large exposures seventy-five yards west of the station, the stratified beds being altered to a schist holding mica, and the granite being in the shape of a huge dyke-like mass, which is brownish-gray and felspathic; the main body of the granite terminating about a fourth of a mile west of this point. On the road thence to Smith's Mills, slates and limestones show at intervals, with occasional dykes of the granite, which do not appear to have greatly broken up the rock in contact with them. The main granite area apparently terminates on this road near its junction with the road to Griffin's Corners, on lot four, range seven. In this direction the limestones and slates are both highly altered and micaceous; but as we approach Smith's Mills the micaceous aspect generally disappears, and the rocks resemble those along the south side of Fitch Bay.

Smith's Mills.

The limestone of Smith's Mills is bluish- and blackish-gray and the associated slates contain cubes of iron-pyrites, thickly disseminated. The rocks sparkle in the sun, probably from the presence of quartz, since no mica is discernible, and veins of calcite and quartz are seen. Under the railway bridge at this place, the rocks in the cutting are much distorted and are traversed by quartz-veins of large size, which are twisted in all directions.

Pyrites appear to be a constituent of these rocks over very large areas, being found throughout the entire Cambro-Silurian series between Lake Memphremagog and the Cambrian near Lake Megantic. Between Smith's Mills and Stanstead, the proportion of calcareous

beds perceptibly diminishes and the rocks become more slaty. Beds of this peculiar black and gray pyritous slate, precisely like that seen about the shore of Memphremagog Lake near Sargent's Bay, and in which the graptolites are found on the east side of the lake, become interstratified to a considerable extent with the limestone beds, proving the unity of the two series and showing that the limestones are probably of slightly later date than the slates. The predominance of the slates over the limestones increases as we go further east into Barnston and Barford, but the distribution of the rocks in this direction has already been given.

Area east of Memphremagog Lake.

Reference has been made in the report for 1886, to certain dark-gray limestones which occur west of Memphremagog Lake, in the vicinity of Peasley's Corners, and at the head of Sargent's Bay; and it was then thought that these might be a part of the graptitic limestone and slate series which carries graptolites of the Cambro-Silurian. At that time fossils had not been found in these limestones, but since that date a few corals have been collected which tend to show that these calcareous beds, though very like in character to those of Cambro-Silurian age in many respects, should, for the area mentioned, be connected with the fossiliferous Silurian strata. The excessively disturbed and intimately infolded character of all the beds in this section, very frequently makes the exact determination of horizons, unless fixed by the presence of characteristic fossils, exceedingly difficult.

Upper Silurian of area north of Sargent's Bay.

Another area of limestone on Memphremagog Lake, viz., that at Magoon's Point, on lot twelve, range two, Stanstead, also presents difficulties in assigning it to any particular horizon. The rock is apparently devoid of fossils, with the exception of a few fragments of crinoid stems, and is highly crystalline, being in places a true marble. It is associated with certain black slates which may be Cambrian or lower Cambro-Silurian. The cause of the great metamorphism is difficult to ascertain, unless it be found in the granitic mass of the point near by, which may here lie at no great depth. In its crystalline character, it resembles the marble of Dudswell, but the rock differs from the Dudswell marble in not carrying fossils of Silurian age. We have therefore regarded it rather as a portion of the Cambro-Silurian graphitic limestone series of the south side of Fitch Bay, which is also seen in Whetstone Island, lying off the point itself.

Magoon's Point limestone.

This island presents peculiar features. The south-west end consists of a considerable dyke of eruptive diorite, altered and sheared till

Whetstone Island.

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 21 J.

it now presents in places the aspect of a talc-schist. This is greenish, or brownish, where in contact with the black and gray limestones, which are the rocks in the immediate vicinity. At the contact itself, the limestone has the appearance of being altered by heat, having a reddish aspect, while the dyke has become soft and schistose. This dyke extends for a considerable distance along the east side of the island, in places weathering rusty like a dolomite; in others through pressure and shearing, resembling a chlorite-schist. Towards the north end of the island, the rocks are black pyritous slates, and these are cut, on the outer or north-west side, by a second dyke, which crosses from the mainland to the north. South of this, the black pyritous slates occupy the west side of the island for nearly three-fourths of its length, where a dyke of talcose-looking rock comes to the shore, beyond which the black slates gradually shade into the graphitic calcareous beds first noted at the south-west end. These limestones, both on the island and on the mainland, contain numerous quartz-veins, and the rocks themselves are much disturbed and often show a very intricate series of crumplings. From the position of the limestone on the west side of Whetstone Island, it is probable that the outcrop seen at Magoon's Point is a part of this series, as already suggested. Certain bands of slaty rocks on the island, furnish excellent whetstones, which were at one time extensively worked, whence the name of the island.

Whetstone rock.

There is yet another well defined area of these graphitic limestones and slates, viz., that found in the southern part of the township of Melbourne, whence it extends across Ely into North Stukely. This occupies a well-defined depression to the west of the Melbourne ridge, and appears to be folded in amongst green chloritic and micaceous schists of pre-Cambrian age.

Ely and Stukely band.

The northern limit of this basin is seen a short distance to the north of the road, traversing range three of Melbourne, whence, to the south-west, the peculiar black graphitic limestone and slates are easily recognized on several roads in the northern part of the township of Ely, between South Ely and Valcourt, just west of the village of Lawrenceville and on the road from North Stukely to Ste. Anne de Rochelle. The breadth of this belt is rarely a mile at any place, and the strata appear to be all highly inclined. In South Ely, they are bounded on the south by black slates, often graphitic, but in which no determinable fossils could be found. These, as seen in a small brook at this place, rest directly against crystalline limestone and mica-schists of pre-Cambrian age.

South Ely.

*Geology of Canada, 1863, p. 809.

To the south of the North Stukely road, in a valley, many large pieces of red and green Sillery slates are seen, which from their general aspect would indicate that outcrops of these rocks exist in the immediate vicinity. They were not, however, found in place, though the presence of blackish wrinkled slates believed to be of Cambrian age, was noted still further to the south on the road from South Stukely to Frost Village. These probably form the lower part of the Cambrian and Cambro-Silurian basin just described. South Stukely and Frost Village.

To the north of Memphremagog Lake, the road from Magog to the Montreal road, which leads from Sherbrooke to North Stukely, shows frequent outcrops of blackish and grayish, sometimes thickly ochre-spotted slates, like those which contain the graptolites near the lake shore. Similar slates extend west on the Montreal road to the crossing of the brook near the inlet to Brompton Lake. They are well characterized by the presence of pebbles of slate and sandstone, and a short distance beyond this brook are underlain by black, green and purple slates with beds of quartzose sandstone of Cambrian aspect. This brook, flowing into Brompton Lake, may be regarded as constituting the western limits of the Cambro-Silurian in this direction. Area north of Memphremagog Lake.

On the road leading north to Key Pond or Webster Lake, similar slates are exposed to the western shore of the pond. They are of the series which is described in the Report for 1886, as occupying the valley of the St. Francis in the township of Brompton, and, on Webster Lake, they are in contact with serpentines and diorites, which appear to come to the surface along the line of contact between the Cambro-Silurian and Cambrian rocks. West of this, to Brompton Lake, serpentines and diorites, with occasional ledges of greenish, grayish and purplish slates, are the prevailing rocks, and these latter may be classed with the Cambrian system. Webster Lake. Brompton Lake.

It will be observed, that in the areas east of the St. Lawrence and Champlain fault, the characteristic limestones and shales of the Calciferous, Chazy and Trenton do not appear. No beds resembling those of the Ottawa and St. Lawrence basin, marked by the typical fauna of these formations there (with the exception of those at St. Dominique) have been recognized, though the stratigraphical sequence of formations and the similarity of the fauna obtained from the beds of the eastern area, in many respects, to those found in the typical Cambro-Silurian formations of the western area, enables us to determine pretty closely the several divisions of strata which we have just described.

Rocks of Montreal Island and vicinity.

The various formations found along the lower Ottawa and on the Islands of Montreal and Jésus, have been described in the earlier reports of the Geological Survey, more particularly in the Geology of Canada*; but, as the volumes containing the descriptions of these localities are now with difficulty accessible, it may be useful to repeat here some of the principal geological features pertaining to the several Cambro-Silurian formations as there developed.

The lowest of these, viz., the Calciferous, with its gradual passage downward into the Potsdam sandstone, has a somewhat extensive development along the lower Ottawa and that portion of the St. Lawrence from the junction of the Ottawa at the village of Ste. Anne's upward for some miles. A small outcrop of the characteristic Calciferous sandy limestone shows at the south-western extremity of the Island of Montreal, at the north end of the railway bridge and in cuttings on the Canadian Pacific railway at Ste. Anne's station. The beds are flat-lying, or nearly so, and the Potsdam sandstone appears on Isle Perrot, on the other side of the Ottawa River. East of Ste. Anne's, towards Pointe Claire, the country is largely drift-covered, and outcrops are very rare, so that the eastern limit of this formation cannot be definitely fixed in this direction. The western side of the island affords few exposures, but at the first rapid in the Rivière des Mille Isles, about two miles above the village of St. Eustache, Calciferous beds appear on either side of the stream. A small outcrop also appears on the northern side of Isle Bizard, but these outcrops are soon covered by drift or by beds of the overlying Chazy limestone. Similar outcrops of the Calciferous show on the Rivière à la Graisse, in the village of Rigaud, but the drift deposits along the lower Ottawa are so continuous that the rock is very rarely seen.

West end of Montreal Island.

St. Eustache.

Rigaud.

The succeeding formation, the Chazy, is imperfectly developed in this direction. An outcrop of limestone appears on the west side of Isle Bizard overlying the Calciferous, containing an abundance of fossils, but the sandy and shaly beds of the Ottawa River area are absent from this locality. In fact, this portion of the Chazy formation was observed at only one point in this locality, viz., in a quarry at the east end of the Canadian Pacific railway bridge near Sault au Récollet station; though in the development of this formation along the Ottawa River, between Grenville and Carillon, the sandy and shaly beds form

Isle Bizard.

Sault au Récollet.

*Geology of Canada, 1863, pp. 114-116, 131-133, 136, 141-145.

a very considerable thickness, underlying the fossiliferous limestone which constitutes its upper part.

The limestones have, however, a very considerable extent on Isle Jésus, and a number of fine quarries have been opened in the beds in the vicinity of St. Martin Junction, where the strata lie nearly flat. Chazy limestones also appear on the River St. Lawrence at Pointe Claire, but are overlain by the beds of the Black River formation a short distance inland. Chazy limestones also show on the western side of Montreal Island near the village of Cartierville, opposite Bord-à-Plouffe but the greater part of the island is so uniformly covered with deposits of clay and sand that rock outcrops are rarely seen.

St. Martin Junction.

The overlying Black River formation, is seen at widely separated points on the island of Montreal and the adjacent Isle Jésus, but it was found impossible to trace this formation with any degree of exactness. The only definitely recognized outcrop on the first-mentioned island, occurs at Pointe Claire, where, in an escarpment between the line of the Grand Trunk railway and the village, about fifty feet of the Black River limestones are exposed. The outcrop is the site of very extensive quarries, from which much of the stone for the piers of the Victoria Bridge at Montreal was obtained. It is underlain by the Chazy limestone on the shore of the St. Lawrence, in the village, but does not extend to any great distance in either direction. The beds are nearly flat, or dip to the south-east at an angle of 1° to 3° and certain strata are almost entirely composed of *Tetradium fibratum*, a characteristic fossil of the Black River formation.

Black River at Pointe Claire.

Fossils.

To the south-west and west of Montreal Mountain, the island is mostly clay-covered, and the next outcrop of these strata recognized by us was at St. Vincent de Paul on the west bank of the Back River about four miles below Sault au Récollet. The west bank of the stream at this place is a cliff chiefly composed of Trenton limestone, but on the shore several feet of the rock have an abundance of Black River forms, among which were recognized *Gonioceras anceps*, *Actinoceras Bigsbyi*, *Columnaria Halli*, *Streptlasma corniculum*, *Tetradium fibratum*, *Cyrtodonta Huronensis*, *Murchisonia gracilis*, *Glyptocrinus*, *Stromatocerium rugosum*, *Strophomena incurvata*, *Licrophycus* like *L. Ottawaensis*, *Pachydictya acuta*, *Orthoceras*, *Cyrtoceras*, etc. This band does not show at the upper part of the cliff.

St. Vincent de Paul.

Fossils.

The limestones of the Trenton formation have by far the widest distribution of any of the Palæozoic rocks in this vicinity. They are well developed about the city of Montreal, and the quarries about Mile End and at Côte St. Michel are situated in this formation ; while a some-

Island of Montreal.

what broad ridge of the same rock extends lengthways of the island and is crossed by the roads north-west from Longue Pointe and Pointe aux Trembles towards the village of Rivière des Prairies. These beds show also on the east side of the Back River opposite St. Vincent de Paul, on Isle Jésus, and on the road from that place to the Pont Viau or Sault au Récollet bridge. They are penetrated by the intrusive rock of the Montreal Mountain, excellent illustrations of the alteration produced being seen on the several roads which lead from the city of Montreal to the Mountain Park.

Lachine.

Trenton limestones also show on the beach of the St. Lawrence at Lachine and for a short distance west, but do not appear inland till the vicinity of the mountain is reached.

Joliette.

On the mainland, north of the St. Lawrence, at Joliette, Chazy and Trenton rocks are both well exposed, as well as on the road leading north-east to Ste. Elizabeth. This locality is referred to by Sir William Logan,* and the presence of the characteristic Black River fossils is there noted. More recently (1881) extensive collections of fossils have been made from this locality, by Dr. Ami, and by Mr. Giroux in 1891 and 1892, and lists of these have been given by Dr. Ami in the "Canadian Record of Science" for April, 1892, pp. 104-108; the whole subject of the Trenton has, however, been so thoroughly discussed in the Geology of Canada, that but little further remains to be said on the subject.

Fossils.

Borings at Montreal.

Some new developments have, however, recently been made in and about the city of Montreal by means of bore-holes, that have been sunk for a water-supply for special purposes. Of these, the deepest has penetrated the calcareous formations for over 2000 feet, the lowest beds reached being of a sandy nature, probably the underlying Potsdam sandstone. As the bore apparently started near the contact between the Utica and Trenton, the thickness of the three underlying formations can not be far from the amount just mentioned. In none of the bores made in the city or its vicinity does the underlying Laurentian appear to have been reached.

Trenton limestone of Montreal.

The exposures of the several formations as seen on the island of Montreal, are too widely separated to afford any conclusive data for determining their thickness, even in the case of the Trenton, which is the most commonly exposed. In this case, the limestones of the formation are found at the very summit of Westmount and nearly to the summit of Mount Royal. This fact, taken together with the occurrence of the Utica shales on the low ground near Point St. Charles

*Geology of Canada, 1863, pp. 148-49.

and on the river opposite the city, as well as the horizontal character of the Trenton ridge to the north-east, tend to establish the existence of a fault of considerable extent on the south-east side of the mountain itself ; while the super position of upper Chazy or Black River limestone upon the Calciferous at the lower end of Isle Bizard, indicate a fault also in this vicinity. It is probable that several such faults occur at various places on the island, consequent on the intrusion of the mountain mass itself, or of some of the many trappean dykes, which extend to Ste. Anne's on the south-west, and to the north and north-east as far as Rivière des Prairies. These will, however, be noticed on a subsequent page.

Probable fault.

The characteristics of the Trenton and Black River rocks as developed in the St. Lawrence and Ottawa basins, will be found stated in detail, in the Geology of Canada, pages 136-176.

Area east of Montreal.

The area east and south of Montreal, between the St. Lawrence and Richelieu rivers, was thoroughly traversed in order to obtain any additional facts relative to the distribution of the several formations which occur there, viz., the Trenton, Chazy, Calciferous, and Potsdam sandstone. The outcrops noted were, however, in most cases widely separated, while the general horizontality of the strata, and the usually level character of much of the surface, largely covered by drift clays in this direction, make the actual determination of geological boundaries impossible.

Valleyfield.

The Calciferous formation is largely developed in the county of Beauharnois, east of the St. Lawrence, and is well exposed near Valleyfield in a quarry on Grande Isle. The beds are here nearly flat, and the formation extends south-eastward to the Chateauguay River at Ormstown, quarries of the characteristic limestone, which is here fossiliferous, being found near the road a short distance west of that place. The formation is also well seen at the village of Huntingdon, in the bed of the stream, though the country between Ormstown and that place shows no ledges in the vicinity of the Chateauguay River. Potsdam sandstone blocks, however, occur in this direction and form ridges fifteen to twenty feet in height and an eighth of a mile or more in length, as at Dewittville. The horizontal beds of the Calciferous also show on the river above Huntingdon, south of which, to the boundary of the state of New York, the surface is occupied with sandy drift, although blocks of the Potsdam sandstone occur. On the road going east, about two to three miles north of the International boundary, the surface, for the first four miles, is occupied with drift sand, in which occur great quantities of sandstone blocks ; but at the village of Manningville, in Franklin, the

Huntingdon.

Huntingdon to Hemmingford.

typical Potsdam sandstone appears in flat-lying beds, and these are exposed at intervals, nearly to the Grand Trunk railway at Hemmingford. Loose pieces of the Calciferous formation come in on this road about one mile west of Hemmingford station. East from this, towards Lacolle, by way of Bogtown, the Calciferous appears at intervals to within about two miles of Lacolle village, where the limestone of the Chazy formation is found, and this extends eastward for about three-eighths of a mile beyond the village to the contact with the Utica shale at the fault.

The Chazy limestone is well exposed in a quarry (Legault's) about four miles north of Lacolle, and on the road to Stottsville, the rock being grayish in colour and containing numerous characteristic fossils. Thence it can be traced northward by a somewhat well-defined escarpment to the vicinity of Grande Ligne. The contact here between the Chazy and the Utica of the Richelieu plain, is well marked by a ridge, which is about one mile north-west of the Grande Ligne station. Here some quarries occur in the Chazy limestone about one mile west of the contact. In these, the rocks dip from N. to N. 40° W. < 15°–20°. A short distance north of this road, the Chazy ridge sinks again to the level of the plain and the country is presumably occupied by the Trenton and more recent formations. From the Grande Ligne quarries, good collections of fossils were obtained by Dr. Deeks. (See appendix.)

Lacolle to Grande Ligne.

Fossils.

The country thence westward, throughout the counties of Napierville and Chateauguay, is level, with occasional ridges of boulders mixed with sand and gravel or clay. No outcrops could be found, but pieces of Chazy limestone, with Calciferous and Laurentian blocks, are scattered about, and no accurate boundaries could be determined. On the road from St. Johns to Napierville, by way of L'Acadie and the Montreal River road, the Trenton limestone was seen in low exposures near the cross-roads about four miles west of St. Johns; and in the crossing of the Little Montreal River, near L'Acadie, the Utica shales were observed, but these were the only outcrops seen in this direction. The area east of Montreal, in Beauharnois, Chateauguay and Napierville counties, was mapped by Sir William Logan and published in the large map of Canada (1866), and in default of any more definite information, the lines as thus laid down have been, for the most part, retained in the accompanying map. As thus indicated, it may be said that the Potsdam sandstone, which in this section is evidently the lower part of the Calciferous formation,* extends from the boundary

Area east of Montreal.

*The Potsdam and Calciferous formations of Quebec and Ontario. R. W. Ells. Trans. Royal Soc., Can., vol. XII., sec. IV., 1894.

between New York and Quebec, in a gradually narrowing area, of which the western limit is outlined from the vicinity of lot eighteen, range one, Hinchinbrooke, to the Chateauguay River near Ormstown, whence it follows closely the course of the stream for nearly ten miles, turning then westward towards the St. Lawrence and crossing that river about midway between Valleyfield and Beauharnois. Westward it occupies a large part of the seigniories of Vaudreuil and Soulanges, to the shore of the Ottawa River, as far west as Rigaud Mountain. Its eastern and northern margin leaves the St. Lawrence at Beauharnois village. Thence it keeps to the east, and crosses the Chateauguay River about seven miles from its mouth, after which the eastern outline of the formation turns southward and in an irregularly curving line continues east of the Chateauguay and English rivers to the International boundary south of Hemmingford, as already noted.

Limits of Potsdam and Calciferous.

The Calciferous limestones occur in two areas separated by the Potsdam sandstone just described. The western area comprises the greater part of the county of Beauharnois to the St. Lawrence River, west of the Potsdam outline. The eastern area, as far as we can ascertain, occupies the southern and western parts of the counties of Napierville and St. John with the northern part of Chateauguay, and the western portion of Laprairie. It reaches the St. Lawrence between Beauharnois and Chateauguay Basin, where the overlap of the Chazy formation occurs, the line between the eastern limit of this formation and the Chazy being largely conjectural. The northern limit of the Chazy reaches the St. Lawrence about two miles below Caughnawaga village, being succeeded in regular order by the Trenton formation, which, in its eastern extension, can be seen near St. Johns', as already noted; while the Utica shales, seen near L'Acadie, extend thence northward and westward to the St. Lawrence, and, with the Lorraine, occupy most of the St. Lawrence basin east of that river for some miles.

Areas of Calciferous.

Chazy boundary.

Concerning the Potsdam sandstone, which has been generally considered to form the upper member of the Cambrian system, the following remarks may be made. It is described in the Geology of Canada† as "traceable from St. Lawrence County, New York, into Canada, where it has its greatest development in the county of Beauharnois." * * * "The formation fills up the inequalities of the underlying Laurentian series; and in New York the lowest part is described as a coarse conglomerate, deriving its material from the subjacent gneiss, and containing rounded masses of quartz, some of which are eight inches in diameter, held in

The Potsdam sandstone.

*Annual Report, Geol. Surv., Can., 1887-88, vol. III. (N.S.), p. 83 K *et al.*
†Geology of Canada, 1863, pp. 87-90.

a fine-grained matrix of silicious sand. At Potsdam (N. Y.) the rock appears to be a fine-grained yellowish-brown, very evenly bedded sandstone, affected by a multitude of parallel vertical joints."

Base of the Calciferous formation.

As no work has been done in this region by which additional facts have been obtained beyond those mentioned in the report just quoted, it is here deemed unnecessary to give further details of this area, which is fully described on the pages already referred to. It may, however, be said that, in view of all the evidence, both palæontological and stratigraphical, it has been considered most in accordance with the facts, to regard the Potsdam sandstone formation, as developed in the St. Lawrence and lower Ottawa areas, as the continuation downward of the Calciferous, and to consider these two members as constituting the basal portion of the Cambro-Silurian system. No defined break between the Calciferous limestone and the Potsdam sandstone has yet been observed in Canada.

Cambrian.

The classification of certain areas as Cambrian, in the south-western portion of the province rests, to a large extent, upon stratigraphical position and lithological characters. In regard to most of these rocks, however, there can be no doubt as to their position, since from the conclusions already published for the areas south and east of Point Lévis,* it is plain that the lower portion of the fossiliferous Quebec group, by which we mean a large part at least of the division commonly styled "Sillery," and the portion intermediate between this and the crystalline schists of the pre-Cambrian anticlinals, must be assigned to this system.

Sillery division of the Cambrian.

In the portion of the province more directly under discussion, areas of rocks which have been regarded as of upper Cambrian age occur, not previously pointed out and which call for a somewhat fuller explanation. Of these the most westerly is that which, in its northern portion, viz., that south-west of Point Lévis has been described at some length in the previous report.* In this, the red and green shales and hard sandstones of the Sillery formation are stated to occur along the line of the Grand Trunk railway between Lyster and Stanfold and on the Becancour River, to the fault separating them from the Trenton-Utica and Hudson River rocks already described ; and in this area they "form the western side of a synclinal basin, the eastern edge of which appears at Inverness and Ste. Sophie."*

*Report, Geol. Surv. Can., 1887-88, vol. III. (N. S.), p. 62 K.

Further to the south-west, these rocks are traceable in occasional outcrops, the surface being largely drift-covered, though Bulstrode and Horton, in a gradually narrowing belt to the St. Francis River, where, at the falls, about three miles south east of Drummondville, they appear in a band about a mile in width, overlapped by black limestones of Trenton aspect on the east, and in the vicinity of Drummondville, by the black slates holding graptolites, already referred to. Between the south-west branch of the Nicolet, a short distance below Ste. Clothilde, and the St. Francis, the surface is largely drift-covered, with coarse sand and gravel and no rock is seen; so that for this portion the outline of the Sillery must be conjectural.

St. Francis River belt.

South of the St. Francis, in Wickham and Acton, and north of the Grand Trunk railway, the outcrops of these rocks are also limited, but are seen at intervals, and no other rocks of the overlying series appear. It is probable, therefore, that the Sillery formation extends in a gradually widening area to the line of the railway mentioned, having its eastern limit near the crossing of the Moose River about five miles east of Actonvale station and its western limit a short distance, probably about one mile, west of Upton station. Between these two points, outcrops are quite frequent of the peculiar greenish-gray sandstone of the Sillery, with red and green slates. Further south, in Roxton and Milton, the Cambrian area assumes much larger dimensions, having a breadth, from east to west, of about seventeen miles. In the vicinity of Roxton Falls, the sandstone portion of the formation is well displayed and thence to the south-west through Roxton Pond village and further through the town of Granby, these rocks form a prominent ridge which is a marked feature in the landscape. This sandstone ridge extends into the township of East Farnham, and its most southerly recognized outcrop is on the third range of West Farnham, near the township line of East Farnham. The sandstones are here associated with red and green slates and are most abundantly developed along the eastern portion of the Sillery area.

Grand Trunk railway west of Richmond.

Granby ridge.

West of Roxton Falls, on the road to Milton, the sandstones become less prominent, and frequent outcrops of red and blackish-gray slates are seen. Near the line of Milton township, several small knolls of diorite appear, but along the roads through St. Valerien, and thence to Milton Corners, the red slates of the formation have a very extensive development, outcrops of the sandstone appearing at intervals. These rocks continue across Black River to the adjacent township of

Granby to Abbottsford.

St. Hyacinthe, where also ridges of the sandstone are seen which extend, to the south-east, to about the centre of the mass of Yamaska Mountain, and are there in contact with the Trenton slates and limetones which occur east of St. Pie and St. Dominique, though the country in the vicinity is largely drift-covered, and the actual contact is concealed.

In the township of Granby, the red slates of this formation are well exposed on the road from Abbottsford to Granby village. About Mawcook to the north, and to the south-west on ranges of Papineau, Ste. Seraphine and St. George, they crop out in frequent ledges, with occasional locally-developed masses of sandstone. On lot fifteen, range nine, Granby, a quarry was opened in red and green slates, and a large quantity of rock extracted, about twenty years ago. The beds cleave to the south-east, but the cleavage is not sufficiently well defined to make good merchantable slate, possibly because the excavations had not reached a sufficient depth. In some of the lower beds, the cleavage appears to be curved, and in places is transverse to the bedding, while in others the rock itself seems to dip to the south-east at a high angle. A second quarry was opened about one-eighth of a mile west of the large one, but not much rock was removed. From that extracted, the slates appear very similar in character and colour to the stone from the Rankin Hill quarry, Acton, being a dark red.

Slate quarries.

The slates of Mawcook are in places traversed by irregular small quartz veins, and slight traces of copper appear in some of the harder quartzose bands, but this is of no economic value. A small quarry for local flagging, has been opened in the western edge of the red slate belt, about one mile and a half east of the village of L'Ange Gardien, but the slate is of inferior quality and is, moreover, cut by dolerite, presumably from the Yamaska Mountain. In the township of Acton, quarries have been opened in the red slate portion of these rocks on lot twenty-eight, range one, and on lot twenty-six, range five, the latter, known as the Rankin Hill quarry has been described in the Report on "the Mineral Resources of Quebec."* Of the former, we have no details of the operations, but no great amount of work appears to have been done.

Disturbance.

The rocks of this area appear to have been thrown into a series of folds, and probably some of the synclines are overturned, as is the case with similar rocks about Lévis and along the lower St. Lawrence. The description of the Sillery rocks given for that region in the report for

*Annual Report, Geol. Surv. Can., 1888-89, vol. IV. (N.S.), p. 129 K.

1887-88, p. 64 K, answer equally well for the areas now under discussion.

The sandstone ridges are local in their development, and the red shade of the slate frequently passes into green. From the relations of the overlying Trenton limestones on either side, the contact on the west appears to be due principally to faulting, while in the south and east it is more of the nature of unconformable overlapping. Contacts with the Trenton.

The third area east of the St. Lawrence is that found in West St. Armand. This consists of a narrow tongue of Cambrian rocks extending from the state of Vermont for about three miles and a half north of the boundary, where it has a breadth of not more than a mile and a quarter. It is separated from the Chazy of the Phillipsburg section by a line of fault, and it bounds, on the west, the Chazy basin of Stanbridge in its extension south-west from Farnham Centre. Third or St. Armand area.

This area has been described in former reports,* and is well outlined in the atlas accompanying the Geology of Canada. The rocks are there stated to belong to the Potsdam group and to very possibly represent its lowest member. This would appear to be confirmed by the more recent observations of Mr. C. D. Walcott on this series of rocks, by whom large collections of fossils have been obtained on the Vermont side of the boundary, from which he considers these rocks to be very low down in the Cambrian system. † Lower Cambrian.

The thickness of this old series as given by Sir William Logan in 1863, is about 2200 feet. It represents what is known as the Red sandrock of Vermont, and consists largely of dolomitic strata often highly siliceous, white and reddish in colour and with bands of dark-gray and bluish-black slate. Details are given in the report just cited. The northern outcrop of the series terminates in low land on lot 131, west St. Armand, just beyond, and to the west of the forks of the road at that place, where a sharply defined fault is seen between it and the Chazy limestone. The strike of the rocks is a few degrees east of north, and if prolonged this would meet the southern extremity of the Cambrian area of Granby, part of which may represent higher beds in the same series, in this respect following what appears to be a recognized fact in several of these formations, that as we go northward we pass from lower to higher beds. Thickness of the Georgia series (Lower Potsdam).

The eastern limit of this area of dolomitic Cambrian rocks in the state of Vermont, is a short distance south of the village of Highgate Falls, and it is there marked by the presence of beds of limestone con- Northern Vermont.

*Geology of Canada, 1863, pp. 281-286, and 851-52.

†Correlation papers, Cambrian, Bulletin U. S. Geol. Survey, No. 81, pp. 91-117 and p. 360.

glomerate or breccia, along with black slate, having heavy beds of rusty, weathering hard dolomite, cut by small strings of quartz, which, having resisted the weathering better than the containing rock, stand out prominently from the surface, and at times appear as a network of veins. The black slates, according to Mr. Walcott, contain fossils of upper Cambrian age; and from the brecciated masses also other Cambrian fossils were obtained. This band therefore clearly marks the upper line of the Cambrian rocks in this direction, and they are distinctly higher in the scale than the Red sand-rock of the St. Armand outcrop.

Fourth area o Cambrian.

A fourth area of Cambrian age, forms an important belt further to the east and extends from the Vermont boundary in a north-east direction, continuously to Kingsey, on the north side of the St. Francis River, where it is prolonged still further in the same direction and has already been described in a previous report as constituting the Cambrian of Stanfold, Lyster, &c.,* in the counties of Richmond and Wolfe. Its extension to the south-west is depicted on the map of Vermont by Prof. Hitchcock, where it forms the eastern boundary of the Chazy belt already described as extending to the east of Highgate Falls. It crosses from Vermont into the province of Quebec near the line between lots fifty-six and sixty-seven, St. Armand. At this place, about a fourth of a mile east of a cross-road which is one mile south of the Boundary, a considerable hill rises to the left of the road going east, the rock of which is a black slate with large bands of dolomite, cut by quartz-veins, which constitute, in some places, nearly half the mass of the dolomitic portion. Occasionally the rock becomes a conglomerate or breccia, mixed with the dolomite, and some of the limestone masses contain obscure fossils. The general aspect of these rocks is very similar to that noted as occurring in the upper Cambrian, south of Highgate Falls, Vermont. On the road leading south-west from St. Armand Centre, which crosses the Boundary on lot fifty-six, the dolomite bands come in about three-eighths of a mile south of the cross road at that place, with hard grayish sandy slates and quartzites. These are thence traceable to the Boundary, where, just to the west of the road, a prominent ridge composed of similar slates, dolomite and quartzite occurs. Fucoidal markings were observed in the slaty beds. A hill of similar rock rises on the east side of the road leading to Franklin Centre; and, on the road going east, just south of the Boundary, the series of grayish, hard, sandy and occasionally dolomitic slates, like those seen at Frelighsburg, is crossed, and these extend to the village of East Franklin, Vt., which is about three miles and a half

Distribution in St. Armand.

Fucoids.

*Annual Report, Geo. Surv. Can., 1886, vol. II. (N.S.), p. 27 J.

south of Frelighsburg village, on the road to which place, similar slaty rocks are frequently exposed.

Dolomitic bands in Upper Cambrian.

The bands of dolomite just described, may be taken as determining the upper part of the Cambrian for this area, and these can be traced very continuously for a considerable distance to the north-east. They cross the Pike River at Lagrange's mill, one mile and a half north-west of Frelighsburg, a short distance to the west of which place, and in the hills north of the road, great ledges of the quartz-veined dolomite present a folded structure and are underlain by black and rusty slates; the aspect of the rock being precisely similar to that south of Highgate Falls, except that the brecciated-conglomerate does not appear in this direction. These are in turn overlain by the Cambro-Silurian dolomitic slates, a short distance to the west. Further to the north, this contact is seen in the road between East Stanbridge and Dunham, near the forks of the road, on lot eight, range eight, Dunham, and still further north at Sweetsburg village, where, on the road to Brome Mountain, these peculiar dolomitic bands, in twisted blackish gray slates, are well exposed. The strata all along this contact of the Cambrian and Cambro-Silurian, are very greatly disturbed, being twisted in every direction and highly cleaved. No rocks with Calciferous fossils appear anywhere in this direction, and it is probable that the Chazy is separated from the Cambrian by a line of faulting along which the doleritic mountains of Brome, Gale and Shefford have been erupted.

Character of the Cambrian of the Sutton anticline.

The breadth of this Cambrian belt, on the Vermont boundary, appears to be nearly four miles and a half, to where it is limited on the east by the series of underlying green chloritic, mostly schistose, but occasionally massive dioritic rocks. The strata which compose this belt, differ somewhat from those which make up the areas already described. The rocks are largely slates, greenish, grayish or black in colour, with occasionally bands of dark purple. With these are local developments of hard, generally bluish-gray quartzite or quartzose sandstone, veined with quartz and frequently with small blebs of clear quartz. These rocks appear on both sides of the central axis of Sutton Mountain, having a general dip to the north-west on the west flank of that axis, and to the south-east on the east side.

Dunham to Frelighsburg.

About Dunham and on the road to Frelighsburg the characteristic Cambrian rocks of this area are well seen. On the road from Dunham to East Stanbridge, after crossing the series of bluish-gray and black slates and limestone of the Chazy, the conspicuous band of quartz-veined dolomite, already described, is exposed in lots nine and ten, range

seven of Dunham ; with these are associated local bands of generally hard and fine-grained sandstones. Approaching Dunham village at one fourth of a mile west of that place, bluish-gray, gray and occasionally brownish-gray slates occupy the hill, with hard, sandy bands from half an inch to three inches or more in thickness. These were carefully examined for fossils, but as the different beds are much disturbed, no trace of them could be found. The general dip, however, is to the north-west. Occasional dolomite bands are seen in these slates, which probably represent the upper portion of the Cambrian, though they do not lithologically resemble the rocks of the Sillery formation.

Frelighsburg and vicinity.

On the road south to Frelighsburg from Dunham, after crossing these slates in the first half mile, the strata become grayer, and more sandy, are slightly micaceous and similar to those seen in the river at Frelighsburg village, where impressions of fucoids were recognized. It is, apparently, in the upper portion of this series that the dolomite bands occur which are seen at Lagrange's mills and on the road to St. Armand Centre about half a mile east of the latter place, whence they are traceable to the boundary of Vermont, where they have been already described. East of Frelighsburg, on the road to Abercorn, these sandy, gray, micaceous slates extend for about one mile and a half, and about one mile west of Abbott's Corners they are in contact with green chloritic schists, slightly micaceous in places, which thence extend easterly to the valley of the North Branch of the Missisquoi River near the village of Abercorn.

West of Dunham, on the straight road towards Riceburg, the band of hard dolomite is seen a short distance beyond the crossing of Gear Brook, about half a mile west from the village corner ; while north-east, towards Sweetsburg, these upper Cambrian rocks keep just to the west of the road as far as the forks on lot seventeen, range four, Dunham. They are also well seen on a road going east, for a mile or so between lots thirteen and fourteen. On a cross-road on lot fifteen, a tongue of calcareous and slaty rock comes in on the line between ranges four and five of the same township. The hard, cleaved Cambrian slates here form an abrupt slope on the east, and this ridge keeps a short distance to the east of the main Sweetsburg road as far as the cross-road on lot seventeen, range four. This cross-road passes over a steep ridge of hard dolomitic rock, which is sometimes highly quartzose and slaty, often rusty-weathering, and this can be traced southward to the road from North Sutton to Dunham. It forms a prominent ridge to the south of Sweetsburg. On the road going back to Sweetsburg, along ranges two and three, the rocks are all slates, brownish-gray and grayish, hard, sandy or quartzose,

Sweetsburg.

cleaved to the south-east, but the dip of the banding is generally to the north-west. Near the top of a high hill on lot nineteen, range one, beds of hard gray quartzite and slate dip N. 55° W. < 75°, the rocks being well-bedded. This point is 350 feet above the river at Sweetsburg, and between this outcrop on the north slope of the hill, and the forks of the road from West Brome, the hard quartz-veined dolomite band again shows in the fields and along the road. North of Sweetsburg, this again appears and extends to the mountain near the forks of the road between lots three and four, range one, East Farnham. It is here overlain to the west by the calcareous slates of Cowansville, which thence continue along the west side of Brome Mountain to West Shefford. This band of dolomite, with the associated black and gray slates, may therefore, in this direction, be taken as limiting the Cambrian on the west, as far as the Brome Mountain.

Waterloo.

To the north of this mountain, about Waterloo, the rocks, classed as Cambrian, are believed to be such because of their stratigraphical position between the green chloritic schists and the Trenton-Chazy limestone, and from their general resemblance to those just described. They consist for the most part of grayish and greenish-gray sandy slates, with occasional hard quartzose bands. The same hard, green, slaty rock, with bands of black and gray and occasionally hard, greenish-gray quartzite, are seen as far as Boscobel Corner, and also on the road between that place and Knowlton Falls. At Bethel or North Ely, hard sandstones with gray and black slates occur, the whole resembling the lower Sillery, and going eastward from this place, great ledges of green and gray hard sandy slates with quartz-veins, dip N. 50° W. < 70°; this is on lot twenty-four, range four, Ely. The probable base of the Cambrian in this direction, is seen near lot one, range one, Melbourne, on the road where it crosses into the township of Ely. At this place, there is a hill of conglomerate rock, containing pebbles of white quartz and pieces of slate, which resemble the schistose-conglomerate beds described in the report for 1886, (p. 26 J) as occurring at Stoke Mountain, Sherbrooke, &c., and which there form the base of the Cambrian rocks. Like them also, the rocks at this place are somewhat schistose and are associated with bands of hard sandstone and greenish slate. These conglomerates appear to be local developments, but the characteristic green slates and quartzites of this series can be traced for miles.

North Ely.

Conglomerates.

Grand Trunk railway west of Richmond.

Along the line of the Grand Trunk railway, after passing the green schistose rocks which extend from Richmond westward to within two miles of Lisgar station, Cambrian rocks are again seen. The first exposure of these is half a mile east of the 71st mile-post, where there

is a cutting in hard greenish quartzose, and quartz-veined rocks, which may represent the lowest member of this system. A quarter of a mile west of the same mile-post, ledges of greenish-gray, somewhat sandy slates, like those already described, dip N. 60° W. < 60°. These are also veined with quartz. At Lisgar station, which is one-eighth of a mile west of the 69th mile-post, ledges of black and gray slates, hard and sandy, have the same dip. A mile and a half further west, black wrinkled woody-fibred slates, quartz-veined and crumpled, and containing scattered pebbles of large size of slaty sandstone and of dolomitic limestone, seem to indicate the presence of an overlap of Cambro-Silurian slates. Beyond this, several cuttings are seen in blackish and bluish-gray, sometimes calcareous, slates with pebbles of sandstone and slates, the age of which cannot be determined by fossils, but which also appear to be more nearly allied in character to the Chazy-Trenton than to the Cambrian rocks.

Lisgar.

Further north, on the St. Francis River, the Cambrian rocks are well exposed. After passing the green chloritic schists, which we may remark are similar in character to those seen at St. Armand Pinnacle, near the Vermont boundary, altered gray slates, occasionally of a bluish tinge, occur. These are followed by reddish-brown or purple slates, which, a little lower down the river, have been quarried.

Kingsey.

About lot five, range one, Kingsey, heavy beds of grayish quartzite dip N. 70° W. < 75°. These are sometimes coarse and full of grains of quartz and have interstratified beds of greenish slaty rock carrying large veins of quartz. These are again succeeded, a little lower down, by reddish-brown and purple slates, and these again by bluish-gray, greenish-weathering slates, which dip N. 80° W. < 70° and which extend to about lot eight, range two, Kingsey. These slates produce a series of rapids in the river. They are all much twisted and quartz-veined, and resemble the greenish slates which we have classed as Cambrian and which overlie the crystalline schists in Inverness and elsewhere to the north of Richmond. Below this place no rocks occur along the river, till the black Trenton limestones of L'Avenir are met with on lot six, range two, Kingsey township.

L'Avenir.

Precisely similar rocks extend to the north-east and have already been described and mapped for the area north of Richmond, in the Report and map for 1886. An area in the township of Kingsey composed of dark red or purple and green slates, with bands of quartzite and hard grit, begins near French village, where it is unconformably overlapped by the black graphitic limestones and slates of the Trenton, and this extends north-eastward into Shipton and Tingwick.*

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), pp. 27-28 J.

Another important area of these Cambrian rocks, is that seen on the east side of the Sutton Mountain anticline. These rocks are presumably, in part at least, the equivalents of the prolonged belt along the west side just described. The rocks of this area, however, differ in some respects from those of the west side of the anticline, more particularly in the presence, at various points, of eruptive rocks, such as diorites, &c., which in places are associated with serpentine and soapstone.

Area east of Sutton Mountain.

In some respects the Cambrian of the eastern or Missisquoi Valley area, is easily confounded with the rocks of the Cambro-Silurian of the same section. Careful examination, however, enables us to clearly distinguish between the two series, though both are affected by the eruptive masses which form so important a feature in this part of the province.

The principal stratified rocks in this area consist of slates and quartzites. The former are grayish, black, green and purple in colour. The quartzite is generally hard bluish-gray, veined with quartz, but sometimes is a true gritty sandstone, and the slates not infrequently contain interstratified hard sandy layers.

Character of the Cambrian in Sutton and Potton.

The contact between the Cambrian slates and pre-Cambrian schists near the Vermont boundary, is visible a short distance west of Mansonville station on the Canadian Pacific railway. To the east of this place, the rocks are generally black stained slates, much twisted and quartz-veined, and with occasional bands of quartzite. Just west of the station, the crystalline micaceous schists of the Sutton anticline come in, and thence extend westward to West Potton, and along the mountain road to Abercorn. Similar slates and quartzites are seen further north at the eastern extremity of the Bolton Pass road and in the valley of the Missisquoi River. North of Bolton Centre, these slates become much disturbed, and masses of diorite and serpentine are exposed between this place and the line of the Canadian Pacific railway at Eastman. Between Eastman and Orford Mountain, the rocks are both slaty and quartzose, and purple-coloured beds are seen just to the west of the Orford Pond on the road to Bolton Forest. While these rocks are of necessity much altered by the action of the dioritic masses, as is seen in the presence of the serpentines and in the schistose character of some of the beds, they do not, as a series, resemble the crystalline rocks of the central anticline. The construction of the Canadian Pacific railway through this district has furnished excellent opportunities for their study, and a paced section along the portion between Eastman station and Magog may here be described.

Bolton.

Section on the Canadian Pacific railway between Magog and Eastman.

On this section the rocks of the different series, from the Silurian to the pre-Cambrian, both inclusive, are represented. The Silurian dolomitic slates and limestones extend nearly to the line between ranges sixteen and seventeen, Magog, where they are underlain by the black and bluish-gray slates, with beds of sandstone of the fossiliferous (graptolitic) series already described.* These graptolites and associated slates continue westward to the outcrops of the dioritic mountains of the Orford range, which appear to have come through along the great line of fracture near the contact of the Cambro-Silurian and Cambrian systems, the contact with the slates of the former being seen in the cuttings at Miletta station on the Canadian Pacific railway. The dioritic rocks of the mountain thence extend to the middle of Orford Pond, and form a very prominent ridge for some miles both to the north and south.

Graptolitic black slates.

Contact with Orford Mountain diorites.

For some years, the rocks east of this cutting were supposed to be of Cambrian age, but the finding of the lower Trenton graptolites in portions of the black slates, and the general aspect of the strata where not too highly altered to ascertain the original characters of the rocks, have now made it clear that they should be assigned to the Cambro-Silurian system.

Altered character at the contact.

In this cutting, the action of the diorites upon the slates, is well seen. It may be stated that, for forty yards, the rock is mostly a black slate of the pebbly series, highly cleaved; the cleavage planes, where not too much broken, being N. 85° E. $<$ 85°. Then, for twenty-four yards, the colour of the slates gradually changes to a grayish-green tint, and the rock is much more jointed and broken up, the slates having a burnt or baked aspect as we approach the end of this distance, to the contact with a dyke of the diorite. This diorite is also much altered at the contact, being shattered or broken, and slightly scoriaceous near its junction with the sedimentary beds. The dyke has a width of about six feet when the slates again come in, much broken, in a band of ten feet, to the main mass of the diorite, which soon becomes greenish-gray in colour and concretionary in structure. It apparently contains a small quantity of serpentinous matter throughout its mass, and at the end of seventeen yards holds another band of the slate, about two feet in thickness, which appears to have been caught in the outflow. The cuttings extend for eighty yards further, chiefly in concretionary diorite, along the joints of which thin coatings of calcite occur.

* It may here be remarked, that the finding of the graptolites was due to a paragraph in Sir Wm. Logan's note book for 1847, where the presence of these fossils in loose pieces of the black slates on the fifth lot of the fourteenth range of Magog was mentioned. This was noted in the Report for 1866 (p. 31), by Mr. Richardson, but no further attention was paid to their occurrence till our investigation in 1886.

The diorites of Orford Mountain then extend continuously to Orford Pond, the rock varying in character, being in places a hard fine-grained diorite, in others a moderately coarse diabase with crystals of hornblende or pyroxene, and in others a coarse almost syenitic rock, like portions of Brome Mountain. At the east end of Orford Pond, a cutting in serpentine marks the presence of a somewhat narrow band of this rock, which appears to extend for some distance along the western portion of the Orford Mountain chain, sometimes as a pure serpentine, but elsewhere as a serpentinous diorite. In the centre of the cut is a band of black slaty rock, which on examination is seen also to be a serpentine, and the west end of the cutting is in a soft dirty-green similar rock, with what appears to be soft yellowish-green talcose matter, and with the appearance of an altered concretionary diorite.

Orford Mountain diorite.

Serpentine.

The second cutting, which is a short distance west of that just described, begins in a rubbly or concretionary serpentine, light yellowish-green on jointage planes, with an apparently bedded structure in places. This is followed by a band of grayish-green slates, highly altered, about three feet thick, the slaty cleavage well developed in the lower part and looking like a slaty dolomite. This again is underlain by hard generally fine-grained grayish dioritic-like rock which may, however, be a hard altered quartzose sandstone holding clear grains of disseminated quartz, it being almost impossible to determine these sandstones in hand specimens, when highly altered, from the diorites, the latter often having a bedded structure.

Second cutting.

The slates are brownish-gray on fresh surfaces and weather to a reddish-brown. The band of dioritic rock extends for thirty-two yards when serpentine again appears with a breadth of twenty yards. This is generally much shattered, at the end passing into the black slaty variety, which extends for sixty yards, to end of cutting, the rock being a soft talcose-looking slaty serpentine with lumps of harder consistency.

Slates, diorites and serpentine.

The next cut is on the west side of Orford Pond and begins with crushed slaty serpentine for fifteen paces. Then a three foot band of dolomitic rock occurs, extending up the face of the cut, and serpentine again for thirty paces, to a dyke of hard fine-grained dark-gray quartz-diorite, ten paces wide; then serpentine again much crushed and slaty for fifty-three paces to a second band of doloritic-rock seven paces wide; lastly serpentine to end of the cut, for forty paces more. On the road, a short distance to the north, grayish-brown slates occur, cut by diorite, and on the road to the south are purple slates, with hard quartzose grits or sandstones. These are characteristic Cambrian strata.

Cutting at Orford Pond.

Cutting west of the pond.

The next cutting, going west, a short distance beyond the pond, begins with serpentine for sixty paces, then a gap for twenty paces to hard gray quartzose rock, pyritous and rusty-weathering, massive but intersected by joint planes. This extends for forty paces, then a gap to hard bluish-gray dioritic rock for seven paces, to a band of soapstone, rusty and impure. This has a breadth of sixteen paces, and on the right the rock is serpentine, while to the left, hard green diorite extends for one hundred paces to green schistose slates. A short distance beyond, the cutting passes through a band of porphyry, blackish-gray, generally fine-grained, with crystals of black hornblende and an occasional pebble of black slaty rock. This is cut by a dyke of granite, grayish in colour, composed of hornblende, felspar and mica which is in turn cut by small dykes of reddish spotted rock.

Soapstone.

Purple and green slates east of Eastman.

Between this and Eastman, the rocks are slaty and schistose. Some of the beds contain talc and mica, but these are apparently due to local alteration, since these bands are intimately associated with green, gray, black and purple slates of Cambrian aspect. In places these rocks are dolomitic, and the dolomitic slates on the road south from Eastman contain bands of serpentine at several places. On the main road past Orford Pond to Bolton Forest, the several kinds of slates are well seen, the serpentine being intimately associated with the purple and green variety, some of which near the Bolton Forest post-office are quite schistose. After crossing the high trestle at Eastman village, the chloritic and micaceous schists of the central axis are seen in the cuttings to the west, and these extend with a south-east dip to a distance of nearly a mile beyond Eastman station, where the axis of the Sutton Mountain anticline is visible in a small cutting in blackish mica-schist. On the road leading south from Eastman village to the Huntingdon mine, the rocks are principally slates. These are bright green, black and gray, and dark indian-red or purple. They have beds of green and dark-gray grits interstratified with numerous outcrops of serpentinous and dioritic rock. These are exposed at intervals to Bolton Centre, five-eighths of a mile west of which place, their contact with the crystalline schist series is well seen, as well as on the road from that village to Grass Pond, about two miles north.

Road south from Eastman.

Brompton.

To the north of Orford Mountain and in the township of Brompton, the Cambrian rocks seem to have a wider development. Purple and dark red slates are a part of the series at several points, among which may be mentioned the old Montreal road through North Stukely, a short distance west of Fraser Lake, and an area to the west of Brompton Lake, where a quarry has been opened in a fine purple slate of this series, on lot eighteen, range ten, Brompton Gore, apparently in the

extension of the slate belt of Rockland, but further to the east; while on the extension of the same belt to the north-east of the St. Francis River, in the township of Cleveland, similar purple beds are also found. The area about Brompton Lake is broken up by intrusions of diorite and by masses of serpentine, some of which, near the foot of the lake, are of considerable extent. The bluish-gray slates of the Rockland quarries have already been described, and it need only be said of this belt that it is the extension to the south-west of that depicted on the map of the south-east quarter-sheet, (1886), as extending from the St. Francis River between Windsor Mills and the slate quarries of Melbourne and Cleveland, where these rocks have a breadth of between eight and nine miles. The serpentine outcrops appear in this belt almost as far north as Windsor Mills, but these will be described later.

Serpentine of Brompton Lake.

There are two other areas of Cambrian rocks to be described in this section, both of which are limited in extent. The most easterly is an infolded basin in crystalline schist in the townships of Stukely and Bolton, where certain black wrinkled slates, with frequent pieces of purple slates occur to the south of the road from North Stukely to Ste. Anne de Rochelle, underlying the Cambro-Silurian area of slates and limestones. The second area is east of Memphremagog Lake, lying to the north of Fitch Bay, and extending thence to Massawippi Lake. The rocks of this latter area underlie the Cambro-Silurian of the east side of the lake, and rest upon a series of crystalline schists which are held to mark the extension to the south-west of the Sherbrooke anticline in which the copper deposits of Ascot occur. They consist of green, black and gray slates, with occasional bands of conglomerate which are sometimes schistose and which have already been described.* The breadth of this belt of Cambrian slates, sandstones and conglomerate on the road from the upper end of Massawippi Lake to Magog is about two miles in its broadest part near the head of the lake, and similar rocks appear on both sides of the ridge of crystalline schists. They extend south-west past the lower end of Lovering Pond and apparently terminate at Magoon's Point, on the north side of the entrance to Fitch Bay.

Cambrian of North Stukely.

Area east of Memphremagog Lake.

Schistose rocks appear on the road, crossing into Vermont, east of Bear Mountain, about half a mile south of the boundary. These are overlain to the north by the bluish-gray and black pebbly slates of Sargent's Bay, and with them are two small outcrops of black graphitic limestone similar in character to the rock of Melbourne and Richmond. The schistose rocks in this direction look like altered

Vermont, west of lake.

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 27 J.

slaty beds and contain quartz-veins which have been mined apparently for galena, of which slight traces were observed in some pieces of the quartz. They do not resemble the pre-Cambrian schists so much as the altered Cambrian rocks, such as are seen on the Canadian Pacific railway west of Orford Mountain.

Potsdam sandstone referred to the Calciferous.

The areas of Potsdam sandstone north and west of the St. Lawrence, have already been described and mapped. Although a re-examination of this section was recently made, nothing further of importance concerning the distribution of the Potsdam was ascertained, the area being largely drift-covered, and no details can be added to those given in the Geology of Canada of this region.* The Potsdam sandstone is now held to form the lower and sandy portion of the Calciferous formation, constituting, with that formation, the lowest member of the Cambro-Silurian system.

Pre-Cambrian.

Rocks west of St. Lawrence described separately.

In this report the pre-Cambrian areas east of the St. Lawrence only will be discussed. The Laurentian rocks west of that river, more especially in the country north and east of St. Jérome, form a division distinct in character from the crystalline schists of the Eastern Townships. They have been very thoroughly studied by Dr. F. D. Adams both in the field and in the laboratory, and his remarks upon the area will be found in a supplementary chapter.

The crystalline rocks of that part of the "Eastern Townships," comprised in the area here described, have been already indirectly referred to in previous reports, as constituting the most westerly of the three anticlines which are found in south-eastern Quebec.†

Early views as to structure of Sutton Mountain rocks.

The early views as to the structure of this series of rocks have been already given in the report just referred to, as well as their relations to the overlying Cambrian and other systems, and need no further reference in this place. It may, however, be mentioned that the early views of the structure of the Sutton Mountain rocks, according to which they were regarded as a metamorphic portion of the fossiliferous Quebec group, were first publicly challenged by Dr. T. S. Hunt in 1871,§ and subsequently and officially by Dr. Selwyn in 1877. In the Report of Progress for 1847-48 (p. 52), the anticlinal structure of the Sutton Mountain ridge is indicated, but at that date these rocks were

*Geology of Canada, 1863, p. 95.

†Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.) p. 30 and 33, J.

§American Geologist, vol. V. April, 1890, Dr. T. Sterry Hunt, "The History of the Quebec group."

supposed to belong to a much more recent period, viz., to the Hudson River formation. This opinion was subsequently changed, owing to the discovery of fossils in the strata at Point Lévis, by which the rocks of the Quebec group were, in 1860, assigned to the base of the Lower Silurian instead of to its upper portion, although the view that the crystalline schists were the equivalent of the fossiliferous Quebec group was still maintained.

Prominent hill features.

The Sutton Mountain range is the extension into Quebec of the Green Mountains of Vermont. It consists of a prominent ridge, the elevation of the highest point, Sutton Mountain, being stated in the earlier report to be about 4000 feet above the sea.* This elevation does not appear to have been carefully ascertained, however, and is presumably exaggerated, as in the case of the other prominent detached hills, such as Orford Mountain and the Owl's Head, of which the first-named was for many years considered the highest land in eastern Canada, with an elevation of over 4000 feet. Within the past three years the height of Orford Mountain has, however, been carefully measured by aneroid, not only by Mr. Giroux, my assistant, and by myself, but by another gentleman, the three separate observations giving, for the height of the mountain above the railway at its base, only 1930 feet, or about 2860 feet above sea-level. From this we infer that the highest point of the Sutton Mountain range is something under 4000 feet.

Orford Mountain.

Characters of the Sutton Mountain rocks.

Excellent sections are presented along the road from Abercorn to Mansonville which crosses the southern portion of the range, as well as through the Bolton Pass which traverses it between Knowlton village and East Bolton, about ten miles further north, and the anticlinal structure can be well seen on both these lines of section. The crystalline schists of this range may be divided into two principal portions, viz., the gneissic, micaceous, quartzose and talcose schists of the central portions or that in which the axis of the anticline is situated, and a series of green, chloritic, schistose rocks, which constitute an easily separable portion, flanking the central area of schists to the west and extending from the Vermont boundary to the St. Francis in the vicinity of Richmond. This second or chloritic division is recognized also at various points on the eastern slope of the range, but it does not there present so marked a development, and it is possible that its area may be here reduced by the agency of extensive faults which traverse the valley of the upper part of the Missisquoi River.

The line of the anticlinal axis of the central area is easily recognizable, and has been determined on all the roads which furnish sections

*Geology of Canada, 1863, p. 251.

Anticlinal axis of the Sutton Mountain range.

across the range. At the south-west extremity it crosses the road west of Mansonville, in the vicinity, or just to the west, of West Potton post-office, the dip of the crystalline schists thence to Abercorn being north-westerly, while towards Mansonville station the dip is to the south-east. The strata are affected by local crumplings, but these do not disturb the general direction of the dips.

Its position.

On the road through the Bolton Pass, the axis of the anticline passes a short distance west of the fork of the road on lot twenty-eight, range three, Bolton, the same regular divergence of dips being seen to the east and west of this place. On the line of the Canadian Pacific railway, this axis is seen in a small cutting one mile west of Eastman station. Further north, it passes just west of the village of North Stukely, and still further in this direction it is recognized in close proximity to the road through Melbourne Ridge about lot fifteen, range three, Melbourne, whence it continues across the St. Francis River into the township of Cleveland. In all these places the reverse dips from the central axis are easily recognizable for some miles in either direction. This anticlinal structure of the range was discussed and pointed out by Dr. Selwyn in a paper read before the Royal Society of Canada in 1882.*

Chloritic schists.

The distribution of the chloritic schistose portion is somewhat important from the economic standpoint. In character it presents the features of a dioritic rock which has undergone very considerable metamorphism, by which the mass has assumed a schistose structure. The presence in certain portions of amygdules, which have also been drawn out or elongated in the shearing process, is evidence of its originally eruptive origin. The colour varies from dark green to purple.

Copper ore of Pinnacle Mountain.

In their most southerly extension, these rocks are well seen on the road from Frelighsburg to Abercorn. They come to the surface about one mile west of Abbott's Corners, where they have a cleavage to the south-east, though the dip of the bedding-planes is doubtful. Thence to the Pinnacle Mountain, these rocks present good exposures, and are sometimes schistose and at others massive. They are precisely similar in character to the rocks seen at St. Armand and Rochelle in Stukely, and on the hill to the east of Waterloo. On the south side of the Pinnacle Mountain, a deposit of copper ore was worked for several years, but finally abandoned. Similar rocks extend to the valley of the North Branch of the Missisquoi River at the village of Abercorn, on the east side of which the mica-schists appear, as well as in Abercorn village. These rocks dip north-westerly and underlie the green

*Trans. Royal Soc. Can., 1882, vol. I., sec. IV. "The Quebec Group in Geology."

rocks last described. The breadth of these green, chloritic and dioritic rocks in this section is about six miles.

Copper deposits in Sutton and Brome.

In the north-west portion of the township of Sutton, these rocks are well seen on the road from Sutton Junction west through North Sutton. Both here and in the southern portion of Brome, they contain deposits of copper and iron, the characters of which have been given fully in my report on the "Mineral Resources of Quebec."* The mineral-bearing character of these rocks is seen at a number of points thence northward to the St. Francis River, and several mines were at one time located on this belt. These have, however, long since been abandoned, the ore, while being sufficiently rich in copper, not being concentrated in the several lodes in quantity sufficient to repay the cost of its extraction. The belt becomes narrower as we proceed north, and in Melbourne has a breadth of not more than two miles and a half. The general schistosity of the rock dips to the north-west, and it is overlain by the slaty and quartzose beds of the Cambrian as seen in the St. Francis River, already described, and in the township of Cleveland.

Distribution of pre-Cambrian rocks.

That these pre-Cambrian rocks have been greatly disturbed at a comparatively recent date, is shown by the presence of areas of Cambro-Silurian strata, as in Ely and Stukely, which conform in cleavage with the underlying schists, as well as in that of black slates presumably of Cambrian age at several other points.

Geological position of the green schistose diorites.

The age of the green, schistose, dioritic portion is to some extent doubtful. It is evidently newer than the underlying schists of the Sutton Mountain axis and older than the great bulk of the Cambrian slates and quartzites. It therefore apparently constitutes an intermediate series, having, in certain places, bands of black slates and hard sandstone or quartzite, as at Brome and Richmond, which tend to associate it, from a lithological point of view, more closely with the lowest Cambrian than with the underlying schist. As its volcanic origin is plainly seen in its dioritic and frequently amygdaloidal character, it appears to coincide, to some extent, with division 2 of Dr. Selwyn's classification,† viz., the volcanic group, which he supposed to be probably Lower Cambrian or Huronian. The great degree of schistosity found in the rocks of this area, has doubtless been superinduced at the same period in which the slaty and schistose structure was imparted to the underlying series, as well as probably to the overlying Cambrian slates.

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*Annual Report, Geol. Surv. Can., 1888-89, vol. IV. (N.S.), pp. 16-18 K.

†Report of Progress, Geol. Surv. Can., 1877-78, p. 3 A.

Pre-Cambrian east of Memphremagog Lake.

The only other area of rocks in this section which may possibly be of pre-Cambrian age, is that seen in the extension of the Sherbrooke anticline which, in this direction, continues from Massawippi Lake nearly to Memphremagog Lake. On the road from Magog to Fitch Bay, past the east side of Lovering Pond, green mica-schists are seen at the brook-crossing, just south of the Stanstead township-line, on lot twenty-eight, range seven, of Stanstead. They here underlie black, wrinkled, quartz-veined slates of Cambrian aspect, and are exposed nearly to the village of Fitch Bay, at which place also they are underlain by similar slates, the position of the latter being presumably due to overturned structure, and possibly to faulting. On the road from Massawippi Lake to Fitch Bay, one-half mile from the forks of the road, a hill of green chloritic schist with some whitish mica, occurs; dip N. 55° W. $<$ 75°, while greenish and grayish mica-schists with clear grains of quartz are seen along the road south of the Bunker Hill ridge which extends from Massawippi Lake to Fitch Bay. As we approach the latter place, the green schists recede from the road and ledges of black and bluish-gray pyritous slates come in, dipping N. 50° W. $<$ 60°. These slates hold sandy bands and the surfaces are frequently minutely wrinkled, while in other places they are smooth and shining, and contain small irregular quartz-veins. They are distinctly different in character from the schistose beds, and in the former maps of the area were classed in the Upper Silurian series like the rocks west of Sherbrooke.

Fitch Bay.

The green chloritic schist apparently constitutes the bulk of the ridge known as Bunker Hill, to the south-west of Massawippi Lake. The extension of this ridge to the west of Fitch Bay is seen in similar chloritic schistose rock on the road ascending the hill to Georgeville, as well as on the road to Georgeville from the Narrows, about two miles s uth-west of the village of Fitch Bay. The rock has very much the same character throughout, viz., that of a schistose altered dioritic rock, occasionally with micaceous bands, and often containing clear grains of quartz. Ledges of this rock crop out as far west as the road from Magoon's Point to Georgeville, near the crest of the ridge, on lots thirteen and fourteen, range two, Stanstead. These rocks apparently are more closely allied to the green chloritic schists of the west slope of the Sutton Mountain area than to the gneissic schists of the central axis. They do not appear on the east side of Memphremagog Lake south of Fitch Bay, the position which they would have occupied in their extension being taken up with granites and black slates and by amygdaloidal diorites. This whole area is so greatly affected with dykes and faults that formations of very diverse age are now intimately associated.

Volcanic and Plutonic Rocks.

Under this heading must be included a very considerable variety of rocks, such as granites, syenites, diorites, dolerites, diabases, serpentines, traps, etc., evidently of several different ages. Many of these occur in low-lying outcrops, while others rise into elevations, and constitute some of the most prominent mountains in the province of Quebec.

Various kinds of volcanic rocks.

Among the most conspicuous as well as most recent of these, are the granitic masses of the east side of Lake Memphremagog and the great series of doleritic hills on the west and north of that lake, as well as those which rise from the comparatively level plain of the St. Lawrence River basin. With these also must be included certain dykes of diabase which cut the fossiliferous rocks of Lake Memphremagog and other places. The anorthosites of the area north of the St. Lawrence and other eruptive masses which are also found in the Laurentian series of crystalline rock, while newer than the limestone and gneiss which they penetrate are presumably older than the diorites of the Eastern Townships.

Dykes at Lake Memphremagog.

Concerning the dykes which occur around Memphremagog Lake, it may be said that some are massive green diorites, while others are talcose in aspect and schistose in structure, the schistosity being doubtless due to the great amount of pressure which appears to have been exerted on all these rocks, and which has converted the fossiliferous Silurian slates in places into micaceous schists.

Age of granite of the Eastern Townships.

As to the exact age of the granitic rocks of the Eastern Townships, we have no directly conclusive evidence in this region. They have long been regarded as belonging to the Devonian period, but this view was doubtless, to a great extent, due to the fact that they were known to alter rocks of supposed Upper Silurian age, and therefore should be newer than the rocks altered. Since that time, however, it has been ascertained that the rocks penetrated by the granites are not Upper Silurian, but something much older, belonging in part to the Trenton formation and in part to the Cambrian or even to the pre-Cambrian; while in no case yet seen by us in the Eastern Townships of Quebec do granitic rocks penetrate Upper Silurian sediments. From the highly altered character, however, of the fossiliferous Silurian, and from the presence of dykes of trappean rocks, it is probable that the age of the granites is not far from the close of the Silurian period.

Action of the granite upon the strata in contact.

The action of these granites upon the slates in contact has already been described.* The limestones are rendered micaceous, and the

*Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 36 J.

slates frequently changed to staurolitic schist; and this action is the same in all the strata acted upon by the granitic masses whether belonging to the Cambro-Silurian or Cambrian systems.

Granite areas east of Lake Memphremagog.

The areas of granite proper, embraced in the portion of the province to which this report relates, are few, the principal being on the east side of Lake Memphremagog, where at the boundary of the state of Vermont, low-lying ledges of this rock occupy the shore on both sides, and extend on the Quebec side nearly to the head of the cove in Cedarville, on lot four, range three, Stanstead. The granite is also seen in contact with the limestone (graphitic) and slates on Province Island, and on a small island between that and the east side of the lake. In all these places the rocks in contact are highly altered, and the granite near the line of contact is generally of a different character from that of the main mass, being for the most part fine-grained and more felspathic. About Beebe Plain, or Stanstead Junction, and on the road thence to the shore of the lake, the contact of granite with the slates and limestones is well seen, the granite occurring as dykes or protrusions from the main mass into the stratified rocks.

Stanstead.

Another dyke-like mass, distinct from that just mentioned, is seen a short distance west of the village of Stanstead, and is described in the Geology of Canada (p. 435), as extending from the fourth lot of the ninth range to the thirteenth lot of the eleventh range of the township.

Concerning the mode of occurrence of the granite at these places, it is remarked in the volume just quoted that * "it appears to displace the calcareous strata, which it penetrates, as these are observed to dip from it in several places. On the fifth lot of the fifth range, [Stanstead] on the east side of the road, within a short distance of the edge of the granitic nucleus, a great number of dykes of the granite are seen, cutting the basset edges of the limestone beds; the whole having been worn down to a horizontal surface. Some of the main dykes are from two to three feet in breadth, and divide into a multitude of irregular and reticulating branches, many of which are no more than the eighth of an inch wide. In the face of an escarpment, which rises from the granite nucleus to this horizontal surface, a large dyke, of which all the others are probably ramifications, can be traced down towards its source."

Magoon's Point.

Another limited granitic area is found on the shore at Magoon's Point, on the east side of the lake, just north of the entrance to Fitch Bay. It occupies the shore on lots twelve and thirteen, range one,

* Geology of Canada, 1863, p. 434.

Stanstead, where it is in contact with black iron-stained slates, and on several small islands a short distance off the shore, granite also occurs, the alteration of the slates in contact into staurolitic schists being visible in every case.

These granitic rocks furnish a very excellent building stone, and quarries have been opened in both the principal masses, not only on the Canadian side, in that near the boundary, but on the Vermont side as well. The granite is white in colour, with black mica, and has already been described in previous reports.

The series of eruptive mountains like that of Montreal, and including those of the country east to Shefford, has already been very fully examined and described by Dr. T. Sterry Hunt.* The microscopic examination of the rocks of the great eruptive masses of Potton, Orford and Brompton has not yet been completed, though their distribution has been mapped. As a comparison of the principal features of the rocks of the two areas will be of great importance in throwing light upon the relative age of the two series of eruptions a brief description of the most important masses found in the St. Lawrence basin, taken from Dr. Hunt's report of 1858, is here given. Eruptive mountains east of the St. Lawrence.

In the Report of Progress for that year, on page 177, Dr. Hunt says:— "The hills lying to the west of Brome and Shefford are, in the order of their succession, Yamaska, Rougemont, Belœil, Montarville, Mount Royal and Rigaud, all of which are intruded through Lower Silurian strata. A few miles to the south of Belœil is Mount Johnson or Monnoir, another intrusive mass, which, although somewhat out of the range of those just mentioned, apparently belongs to the same series. The mineral composition of these intrusive masses varies considerably, not only for the different mountains, but for different portions of the same mountain."†

The Mountains of Brome and Shefford, in which are included also the Gale Mountain, which constitutes the western part of the mass of Brome Mountain, are in that report regarded as one great trachytic mass. The rock from the west side of Brome Mountain, near the village of West Shefford, is said to be "coarsely crystalline, lavender-gray in colour, and contained a little brown mica, sphene and magnetic iron, but no hornblende."‡ This portion of the mountain is largely a elæolite syenite. Brome and Shefford.

*Report of Progress, Geol. Surv. Can., 1858, pp. 173-188; Geology of Canada, 1863, p. 667, &c.

†Report of Progress, Geol. Surv. Can., 1858, p. 177. ‡*Ibid.*, p. 175.

Rock of Shefford Mountain.

A specimen from the south side of Shefford Mountain is described as "a coarse, grayish-white felspar, with a little black mica, and closely resembled that just described;" while a second piece "contained a little black brilliant hornblende in crystalline grains about the size of those of rice, with small portions of magnetite and yellow sphene, disseminated in a base which, although completely crystalline, was more coherent and finer grained than that of Brome."

Brome Mountain.

The rock of the Brome or Gale Mountain has lately been used in building the church at West Shefford, and makes a handsome stone for that purpose, splitting out in large blocks and dressing easily.

Yamaska Mountain.

Yamaska Mountain is eleven miles north-west of Shefford Mountain. While the mass differs in character at various points, the greater portion is stated in Dr. Hunt's report to be "a granitoid trachytic rock, which differs from that of Brome and Shefford in being somewhat more micaceous and more fissile."* A large quarry has lately been opened on the north-west flank of the mountain, at an elevation of about 400 feet above the Black River at St. Pie, for paving stone for the city of Montreal. The rock quarried is of a dark gray colour, apparently composed of grayish felspar, nepheline, hornblende and black mica, with a little quartz, is moderately fine grained, and splits and dresses well. This rock therefore belongs to the class of the nepheline syenites.

Quarry.

Dr. Hunt further remarks of this mountain that its south-eastern side "offers a composition entirely different from the last, being a dolerite made up of a pearly or white crystalline translucent felspar, with black brilliant hornblende, ilmenite and magnetic iron. This rock is sometimes rather fine-grained, though the elements are always very distinct to the naked eye, while in other portions large cleavage surfaces of felspar half an inch in breadth are met with, which exhibit in a very beautiful manner the striæ characteristic of the polysynthetic macles of the triclinic felspars. The associated crystals of hornblende are always much smaller and less distinct, forming with grains of felspar a matrix to which the larger felspar crystals give a porphyritic aspect. Finer grained bands, in which magnetite and ilmenite predominate, traverse the coarser portions, often reticulating; while the whole mass is occasionally cut by dykes of a whitish or brownish-gray trachytic rock, which is often porphyritic. If, as is not improbable, these dykes belong to the great trachytic portion of the mountain, it would show that here as in Mount Royal the trachytes

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* Report of Progress, Geol. Surv. Can., 1858, p. 177.

are more recent than the dolerites or diorites, but the relations of these different rocks have yet to be made out." *

Of the two mountains just described, it may here be remarked that the more easterly, viz., that of Brome, and Shefford, occurs along the line of contact between the Cambro-Silurian and Cambrian rocks, while the Yamaska Mountain is situated on the line of fault between the Sillery division of the Cambrian and the Lower Trenton formation. It is probable that the Shefford and Brome extrusion is also along a fault line the presence of which is not so clearly indicated as that on which Yamaska Mountain lies, though the amount of dioritic matter is much greater at Brome. Probable line of fault.

Mount Johnson, or Monnoir, is a small mountain as compared with the others of the district, but is sufficiently conspicuous with its somewhat cone-shaped peak. It is situated about six miles north-east of the city of St. Johns and fourteen miles south-west of Yamaska Mountain. The rocks surrounding it are presumably of Utica-Lorraine age, though outcrops are very rare in the flat country from which it rises. Mount Johnson.

Dr. Hunt says of this mountain that "it is composed of a diorite, which in general aspect greatly resembles that of Yamaska except that it is rather more felspathic ; the finer-grained varieties are lighter coloured and exhibit a mixture of grains and small crystals of felspar with hornblende, brown mica and magnetite. Frequently however the rock is much coarser grained, consisting of a mixture of felspar grains with slender prisms of black hornblende often half an inch long and one-tenth of an inch broad, and numerous small crystals of amber-coloured sphene."† Recent investigations on the rock of this mountain show that much of it also belongs to the class of the nepheline syenites.

Belœil, or St. Hilaire Mountain, is situated about midway between Montreal and the Yamaska Mountain, a short distance east of the Richelieu River, near the line of the Grand Trunk railway. It is due north from Mount Johnson, and on the hypothesis that these eruptive masses came up along north-and-south lines of fracture, would probably lie in continuation of the fault which extends from near Lacolle to St. Johns. The rock is generally a grayish elæolite syenite not unlike, in some respects, that of Mount Johnson, as well as that of certain portions of Yamaska Mountain. Belœil Mountain.

Rougemont lies nearly on a north-west line between Yamaska and Belœil. Certain portions of the mass resemble those of the mountains just mentioned. Other portions are a "coarse-grained dolerite in Rougemont.

* Report of Progress, Geol. Surv. Can., 1858, p. 178. † *Ibid.*, pp. 179-80.

which augite greatly predominates ; grains of felspar are present, and a little disseminated carbonate of lime. * * * This rock approaches closely the highly augitic dolerite of Montarville. The olivine which characterizes the latter mountain is also very abundant in two varieties of dolerite from Rougemont. One of these consists of a grayish-white finely granular felspathic base in which are disseminated well-defined crystallized grains of black augite and amber coloured olivine, the latter sometimes in distinct crystals. The proportions of these elements vary in the same specimen, the felspar forming more than one-half the mass in one part, while in the other the augite and olivine predominate. By the action of the weather the felspar acquires an opaque white surface, upon which the black lustrous augite and the rusty-red decomposing olivine appear in strong contrast."* The rock of this mountain resembles very closely that of the basic portion of Montreal Mountain.

Montarville Mountain.

The Montarville or Boucherville Mountain is the most westerly of the series east of the St. Lawrence, and is eight miles due east of Longueuil on the bank of that river. The ólivinitic character of much of the rock of this mountain is pointed out by Dr. Hunt in the report from which the preceding remarks are taken. Two principal kinds of rock here appear, the one a highly augitic dolerite, the other an olivine dolerite in which the olivine is "in rounded crystalline masses from one-tenth to half an inch in diameter, associated with a white or greenish-white crystalline felspar, black augite and a little brown mica and magnetic iron."† Hand specimens from this mountain also show the mass to be similar to the basic portion of Montreal Mountain.

Montreal Mountain.

The rocks of Montreal Mountain have been recently studied by Drs. Harrington and Adams. In many respect the mass as a whole resembles several of the other eruptive masses already described. Dr. Adams remarks concerning its structure.—

"The main mass of Mount Royal, including all that portion of it which overlooks the city of Montreal, consists of a very basic rock having the mineralogical composition of a theralite very poor in nepheline. Under the microscope it is seen to be made up of labradorite, reddish-violet augite, brown hornblende and brown mica. Olivine is present in many parts of the mass, as well as titanite, apatite and other accessory constituents. Nepheline is present only in very small amount and hauyne can be occasionally detected.

"On the northern side of the mountain this theralite is seen to be broken through by a second intrusion consisting of nepheline syenite.

*Report of Progress, Geol. Surv. Can., 1858, p. 184. †*Ibid.*, p. 182.

This rock is much lighter in colour and can be observed to send arms out into the theralite. It is composed essentially of orthsoclase nepheline and green hornblende, with small quantities of plagioclase, pyroxene, garnet and nosean and other accessory minerals. Dr. Harrington has also found sodalite in it in several places.

"Both of these rocks, as well as the Trenton limestone and Utica shales of the neighbourhood, are cut through by a large number of dykes, still more recent in age, which vary greatly in character and have not as yet been thoroughly studied. They belong however to the bostonite-tinguaite-mônchiquite series of dyke-rocks which are consanguineous with, and usually accompany occurrences of nepheline syenite. They are now being studied by Dr. Harrington and myself. A dyke of alnoite found at Ste. Anne de Bellevue is probably also connected with the Mount Royal intrusion."

On the west side of the St. Lawrence and on either side of the Lake of Two Mountains, two prominent hills are seen which may perhaps belong to the same period of eruption as those just mentioned. Of these Rigaud Mountain, on the south side of the lake, rises to a height of 750 to 800 feet above it, and extends south-west for several miles. The rock of the mountain presents different characters at different points. It is in part a reddish orthoclase rock apparently a syenite, like some found in the Laurentian area, generally coarsely crystalline like that of Shefford and Gale mountains; while other portions are largely made up of reddish felsite, which is sometimes porphyritic. Still other parts of the mountain consist of a coarse-grained hornblende diorite, in which crystals of black mica are found. This rock is also like much of the dioritic rock found in the Laurentian west and north of Ottawa.

Rigaud Mountain.

Mont Calvaire, on the north side of the Lake of Two Mountains, is also composed largely of syenitic or granitic rocks, generally red in colour, in places foliated but not resembling the reddish stratified gneiss of the Laurentian. Other portions of the mountain consist of diorite, trappean rocks, gabbros, and on the north-east flank is a patch of brownish breccia, like that found at St. Helen's Island and on Isle Bizard. This mountain, like those of Rigaud, Montreal, etc., appears to be an intrusive mass of comparatively recent date, and to have cut the Potsdam and Calciferous rocks of the vicinity.

Mont Calvaire.

It will be seen that in several of these intrusive masses of the St. Lawrence basin, olivine forms a very important part of the rock constituents, but in none of them has sufficient alteration apparently taken place to produce serpentine to any extent. The

Alteration of diorite to serpentine.

study of the eastern series of these eruptive peaks will, when completed, be of very great interest, since in some of them the alteration of the olivine into serpentine has already been accomplished. A preliminary microscopical examination of some of these was made in 1882 by Dr. F. D. Adams,* from which it was ascertained that the principal mountain masses such as Owl's Head, Orford Mountain and kindred areas, are in some cases altered diabases.

Mountains west of Memphremagog Lake.

In the section to the west of Lake Memphremagog, beginning at the Vermont boundary, and extending in a north-easterly direction thence for about thirty-five miles, is a prominent chain of these eruptive hills. The average breadth of this belt is about four miles, and in it are situated several very conspicuous peaks, among which, beginning at the south, are Bear and Hawk mountains, across the former of which the International boundary line passes; the Owl's Head, rising about 1700 feet above the shore of Lake Memphremagog, and Elephantis or Sugar Loaf Mountain, the eastern outline of whose summit reveals the broken-down lip of a huge crater-like depression on the side next to the lake, occupying the central portion of the mountain mass. In continuation of this to the north, are the Hog's Back Mountain, the Peevy Mountain, and several other prominent hills in the immediate vicinity, the local names of which were not ascertained. These elevations are principally to the west of, and a short distance from, the arm of the lake known as Sargent's Bay, between the lake and the valley of the upper Missisquoi River. From these a chain of medium-sized hills extends through the eastern part of Bolton township to the line of the Canadian Pacific railway, east of Orford Pond, just to the north of which rises the great mass of the Orford Mountain, the highest peak in the chain and probably in this entire section, with an elevation of 2130 feet above the surface of Lake Memphremagog. This mountain extends northward to Orford Lake, beyond which, on the west side of Brompton Lake, are two prominent masses known as the Carbuncle and Bare mountains, the former being about 500 feet and the latter about 750 feet above Brompton Lake, which is about seventy-five feet higher than Lake Memphremagog. Between these hills and the Orford Mountain the eruptive area is indicated by a series of less prominent dioritic masses, in which serpentine occurs to some extent; and, crossing to the east side of Brompton Lake, large masses of the latter rock are conspicuous about the west shore of Key Pond or Webster Lake and between this lake and the lower end of Brompton Lake. Thence to the vicinity of Windsor Mills, small outcrops of serpentinous rocks occur from two to four miles south of that village.

Owl's Head and Elephantis.

Orford Mountain.

Brompton Lake.

*Report of Progress, Geol. Surv. Can., 1881-82, pp. 9 A, 22 A.

The rocks through which these eruptive masses rise are of various ages. For a distance of from three to four miles west of the shore of Memphremagog Lake, the slates are principally of Cambro-Silurian age, with occasional areas of Silurian or Devonian, closely infolded. The more westerly portion of the area of eruptive rocks is associated with rocks of Cambrian age, for the most part slates and quartzites already described, while great areas of dioritic rocks occur in the underlying or pre-Cambrian system. That all of these eruptive rocks are of the same age is not probable, in fact the difference in their character in the different areas, and their associations in certain cases, tend to establish their different ages. Associated strata.

Comparing the eruptive rocks of the Memphremagog Lake district with those of the plain of the St. Lawrence, two principal points of difference at once present themselves. Thus in the western area the intrusions are in rocks comparatively unaltered, and for the most part flat-lying shales and limestones filled with fossils, and where alteration occurs this is at the contact with the dioritic masses ; while in the eastern area, all the rocks from the pre-Cambrian to the close of the fossiliferous Silurian, are in a high state of metamorphism, the several groups of strata are highly inclined, in some cases so much so, that the fossiliferous Siluro-Devonian is found completely overturned and underlying the Cambro-Silurian as on the east flank of the Owl's Head Mountain. This has frequently produced a foliation in the fossiliferous Silurian dolomitic slates, such that these have now the aspect of true schists and the inclosed corals are drawn out of shape and flattened. In certain of the Cambro-Silurian graptolitic slates, the great metamorphism has almost completely destroyed the form of the graptolites, while the rock has become a graphitic schist. In the case of the eruptive rocks, not only the dykes which are found in the Silurian fossiliferous beds are rendered schistose, so as to impart to their mass the character of a talcose or chloritic schist, but certain portions of the large masses of diabase have also assumed a schistose structure, showing the enormous forces to which the rocks of this area, even at a comparatively recent date, have been subjected. Comparison of areas east and west of the St. Lawrence and Champlain fault. Action of the diorites upon the slates.

Fine examples of dyke contacts are seen along the shores of Memphremagog Lake, both on the west and east sides, and on the islands in the vicinity of Fitch Bay. These dykes present very different aspects, some of them being a rather fine-grained diabase, others a whitish felspathic rock, others again are a green talcose schist, while still others are of felsitic granite. The alteration of the sedimentary rocks in contact has already been to some extent referred to. This is seen along the west shore of the lake in the development of crystals, Dyke contacts at Memphremagog Lake.

some of which are apparently dolomitic, in the black Cambro-Silurian slates, and in their hardened and often shattered character, as in the case of the eruptive masses east of the St. Lawrence, and in the intrusion also of dykes of dioritic rock which can be traced direct to their parent mass. Some of these results of metamorphism are also without doubt due to the great crumplings to which these rocks have been subjected; though this would not explain the peculiar local metamorphism witnessed in the slates in contact with the dykes which proceed from the Owl's Head, from Orford Mountain and from the Hog's Back. Around all these, as well as in many other places, local alteration of the slate is seen, its more intense phase extending only a few feet, or, in some cases, inches from the line of contact. Among other places where this is well observed, is a brook flowing down the gorge between the Elephantis and Hog's Back mountains. Here, about 200 yards above the bridge on the road which goes up to the depression in the former, the black and bluish-gray slates are cut by a heavy dyke of moderately fine-grained green diabase which proceeds direct from the Hog's Back Mountain. The slates are locally altered for several feet on either side of this dyke, which has a breadth of about seventy-five feet. Black slates again come in and extend for about five yards to a second contact with the dioritic rock of the mountain mass itself, and here the bluish-gray Cambro-Silurian slates are baked to a dirty or rusty white colour. On the east side of the Elephantis, or Sugar Loaf Mountain, both large and small dykes of hard greenish-gray diorite rock are observed extending from the main mass, and traversing the slates across the bedding planes for some distance from the mountain foot. The slates along the contact of these dykes are locally altered to a hard cherty rock, to which a baked aspect has been imparted. In the micrometer survey of Memphremagog Lake, the position of a number of these dykes along both shores was fixed.

Contact with slates, Elephantis Mountain.

Rocks of Owl's Head Mountain.

The Owl's Head, the most prominent peak in this direction, conspicuous for its cone-like shape, comes directly to the shore on lot sixteen, range ten, Potton. Before reaching the great mass of the diorite, several dykes are seen cutting through the slates. The first of these is forty chains south of Perkins' wharf, and is four feet thick, consisting of green diabase. This is followed for several chains, by pyritous slates, the pyrites being abundant along or near the contact with the dyke. Next comes a second dyke, five chains wide, much of which is a fawn-coloured rock, somewhat schistose, apparently an altered diabase, containing minute garnets and crystals of dolomite, following which are the black altered slates to the Owl's Head diabase.

This rock thence extends for fifty chains, forming the shore of the lake, and the mountain behind rises boldly from the water. At the end of this distance, black, and pebbly slates again come in and form a narrow belt along the lake, for fifty-five chains, or to within twenty chains of the Mountain House wharf. Here they are underlain by the black graphitic limestone of the fossiliferous Siluro-Devonian, which forms a narrow belt of about five to eight chains in width, extending up the hollow behind the Mountain House, where it terminates about ten chains from the head of the small cove which is cut out of these rocks The dioritic rock of the point on which the Mountain House is built, is a breccia or dioritic agglomerate, followed directly after by a diabase rock which thence extends to opposite Round Island, where a band of slates again comes into view. Thence blackish, wrinkled and schistose slates extend to the lighthouse point, in which the "silver mine" is located in a quartz-vein which apparently cuts across the bedding.

The rock of the Owl's Head extends westward to the road along the west side of the mountain and crosses it a little way. Southward it extends nearly to the Bear Mountain, a band of bluish-gray, pebbly slates occurring along the road to Newport, which passes between these two prominent dioritic masses. Diorites, also greenish and sometimes slightly schistose, occur at the International boundary and continue to the lighthouse point on the American side, three-quarters of a mile south of the boundary, where our survey ended.

Talcose rocks.

A dyke of talcose rock, which rapidly hardens after removal from the water, forms a low bluff about one mile north of the boundary. The aspect of this dyke, which is somewhat schistose, is like that cutting the fossiliferous Silurian near Capt. Gully's Cove on the east side, and it is probably an extension of that dyke, as the line of strike would about connect the two places.

While the structure of some of these diorites is schistose, so that in hand specimens, they might almost be taken for chloritic schists, the connection of these with the other massive portions of the dioritic masses and their intimate relations with the surrounding stratified rocks, tend to show the difference in age between this group of eruptive rocks and the chloritic schists which form the Pinnacle Mountain of St. Armand east and which extend to the St. Francis River as already described.*

* An interesting paper has recently appeared by Mr. Vernon F. Masters of Indiana University, in which the dykes of Lake Memphremagog are discussed. Mr. Masters classes them under the head of granites and lamprophyres. One at least of the dykes is a typical camptonite, and they all cut the slaty and calcareous rocks with which they are associated. "Camptonites and other Intrusives of Lake Memphremagog."—Amer. Geol., vol. XVI., July, 1895.

Serpentine of Orford Mountain.

Serpentine very rarely, if ever, occurs in the diorite masses which penetrate the Cambro-Silurian of this section. Thus in the Owl's Head, Elephantis and Hog's Back mountains there is no trace of it as yet seen. In the Orford Mountain the only serpentinous portion is a narrow belt of about 200 feet wide on the west flank of the mountain, which may belong to another eruptive mass. But in the Cambrian division of the Missisquoi Valley, the association of serpentine with diorite is frequently seen in the belt of dioritic rocks which extends from the Vermont boundary to Eastman, and which are in close proximity of the pre-Cambrian as seen on the roads from Bolton Centre to the Canadian Pacific railway and in the country about and to the west of Orford Pond and Bolton Forest. Here also are heavy beds of magnesite with some bands of soapstone, and the rocks present features different from those seen in the eruptive masses near the lake. To the north of Orford Mountain, which apparently is intrusive along the line of contact between the Cambrian and Cambro-Silurian, other large masses about Lake Fraser, Bonallie's or Orford Lake, Long Lake, Brompton Lake and Webster Lake or Key Pond, contain a very considerable admixture of serpentine with the diorite. These masses are surrounded by the purple and green slates and hard sandstones of Cambrian age. The passage of the diorite into serpentine is well seen at several points about the shore of Long Lake, which is near the eastern line of the township of Stukely. Just west of this lake are ledges of slaty serpentine in contact with black and greenish slates, the character of the former being such as to present the aspect of an altered slate, while the slates themselves appear to be frequently highly serpentinous. The two mountains on the west side of Brompton Lake, viz., Carbuncle and Bare mountains, are made up of a mixture of serpentine and diorite; and to the north-west of these, extending for a couple of miles, large ridges of serpentine are seen, bounded on the west by dark purple-red slate, in which the new slate quarry of Brompton Gore is located.

Magnesite and soapstone.

Serpentine of Brompton and Webster Lakes.

Carbuncle and Bare Mountains.

Diallage, old Orford nickel mine.

In several small islands near the eastern shore of Brompton Lake, not far from the old nickel mine, the variety of serpentine known as diallage is seen, the crystallization being in broad platy masses, and patches of red crystalline limestone are found adhering to the serpentine at several points, as if the latter had been an erupted rock through the limestone. At the nickel mine, three-fourths of a mile from the east shore of the lake, on lot six, range thirteen, Orford, the serpentine is mixed with purple and green slates and limestones in thin bands, the bands of slate in places, twisted and caught in the mass of the intrusive rock. These slates are part of the Cambrian series.

At Webster Lake, the slates of the Cambro-Silurian, probably near the contact with the Cambrian, occupy the south end of the lake and the big bay at its south-west angle. The serpentine comes in on the west side of the lake on the north side of this bay. It is generally hard, rubbly, dark-coloured and cherty, with small patches of stiff, hard, somewhat fibrous asbestus of no economic value. The west side of the lake is bordered by a succession of rounded hills, of which four are especially conspicuous. These were all examined for asbestus. They were found to consist of serpentine, for the most part altered or shattered, having a strongly dioritic aspect on weathered surfaces. A large boss of serpentine and hornblendic diorite shows near the lower end of the lake, and two small islets in the northern portion are also composed of hard, rubbly serpentine with diorite. The whole of this serpentine is broken and jointed, and shows no veins of asbestus though occasional patches of a hard, stiff, green, fibrous variety are seen in small thread-like irregular veins from one-eighth to one-sixteenth of an inch in thickness. A vein or band of a hard, whitish-gray, heavy mineral, described as a white garnet, occurs near the foot of a hill of serpentine, midway on the west side of Webster Lake.*

Webster Lake or Key Pond.

Asbestus.

White garnet.

The serpentine belt extends across the country between this lake and the foot of Brompton Lake, in a series of hills, which form a conspicuous ridge along the east shore of the latter near the township of Orford and extend northward to opposite the foot of the lake, or to the line between ranges eight and nine, Brompton. In this belt, on lot twenty-six, range nine, the Brompton Lake Asbestus Company's mine is situated. To the north-east of this, several small outcrops are seen in ranges four and five, Brompton, on lots seven and eight. On the road from Sherbrooke to North Stukely, called the old Montreal road, dioritic rocks come into view about three-fourths of a mile west of the outlet of Lake Fraser, the associated stratified rocks being purple slates and grits. At one mile and a fourth east of the stream from Bonallie's or Orford Lake, knolls of serpentine show on the south side of the road. The prevailing rocks from this to Long Lake, are black and gray slates, presumably of Cambrian age, with occasional outcrops of serpentine. These latter rocks, with diorites, are more extensively developed on a road leading north-east, about midway between the outlet of Orford Lake and Long Lake. In this direction a somewhat extensive belt of these igneous rocks extends along the east side of Long Lake, in a series of knolls, rising occasionally into hills of considerable size, and these continue north, at least as far as Ely Brook, the rocks occurring between the hills being dark gray and black slates.

Serpentine west of Brompton Lake.

* Geology of Canada, 1863, pp. 496 and 608.

On the west of these serpentinous masses, on lot eighteen, in the tenth range of Brompton, are the bands of purple and red slates, where the quarry, already réferred to, has been opened.

Stukely.

The most westerly outcrop of serpentine rocks in this direction, is near the contact of the slates with the crystalline schists, and is seen on a road, to the south, from the Stukely road, on lot twenty-five, range six, Stukely. The sedimentary rocks in contact are black iron-like and grayish slates. This serpentine is very ochreous on weathered surfaces, being decomposed to a depth of nearly one inch, while the rock itself appears to be much broken up. This locality is about half a mile west of Orford Lake. On the post-road, a short distance west of Long Lake, another band of serpentine occurs, which is in direct and sharp contact with beds of black altered slates, and has a very slaty character. A small vein of asbestus was observed here, which was opened by the owner of the farm, but this was soon exhausted and no other trace of the mineral was found.

Asbestus.

Serpentine of Upper Missisquoi Valley.

The most extensive development of serpentine in this area, is found along the valley of the Missisquoi River, from the crossing of the Canadian Pacific railway southward nearly to the Vermont boundary. On the roads connecting this valley with the shore of Memphremagog Lake outcrops of this rock are also seen. South of Bolton Centre, these occur along the east side of the valley; but north of that place several detached hills are observed on the road crossing south-east from Grass Pond, and on the west side of the Missisquoi River. The rocks associated with these serpentines are in nearly every case black and grayish slates with masses of diorites, the great hills of the crystalline schists lying to the west. The most southerly outcrops of the serpentine seen in this direction, are two small knolls on range seven, Potton, about one mile north of the Vermont boundary, and a small outcrop at the forks of the road, lot one, range six. The surface of this area is largely covered with sand drift. No asbestus veins were observed in these serpentine knolls. Further north, on the road from Mansonville to Perkins' wharf, on Memphremagog Lake, a belt of serpentine rock crosses about one mile and a quarter east of Mansonville corner, and has an exposed breadth of nearly half a mile. The nearest rocks on the range are smooth greenish-gray slate and grits with green-gray slates and diorites in the east. The next outcrop of serpentine going northward, is seen on the road from Knowlton Landing to Bolton Pass, on the west slope of the ridge about half a mile east of the Missisquoi River. Here a band of serpentine about fifty yards in width, with black slates on either side, crosses the road, and has lately been opened in the search for asbestus. This is on lot

twenty-eight, range seven, of Bolton. The next cross-road to the lake is from Bolton Centre, eastward, and on this, about a quarter of a mile east of the Missisquoi River, after passing over black and gray slates, a band of serpentine is seen, the first exposures of which are concretionary. The rock, however, is for the most part massive, and is exposed along this road with a breadth of half a mile, the eastern portion being mixed with diorites, which are in turn succeeded by bluish-gray and black slates, in places containing pebbles, and these pebbly slates extend thence to the shore of the lake. This outcrop of dioritic rock appears to be at the contact of the Cambrian and Cambro-Silurian systems.

Asbestus of Bolton.

The serpentine rocks are conspicuous on the direct road from Bolton Centre to Eastman, which passes along or between the chain of lakes, and on which the copper mines of this area are situated, viz., the Huntington and Ives mines. They show with diorites, in the cutting along the old Black River railway, on lot twelve, range eight, Bolton, the stratified rocks in contact to the south being black and greenish-grey slates. Near the Huntington mine, the serpentine is apparently interbedded with green chloritic slates, diorites grayish grits and grayish soft sandy slates. Further north, the serpentine is associated with dark purple-gray and black pyritous slates, and in some places the slates have a markedly red tinge. Small veins of asbestus of a tenth of an inch in length, occur in the serpentine along this road, but no veins of workable size were noticed.

South of Eastman.

On a road which turns off from that last mentioned about two miles south of Eastman and west of the Missisquoi River, a small outcrop of serpentine shows on lot six, range eight, Bolton. The rocks in contact are grayish, green and purple slates. This outcrop is near the contact of these slates with greenish-gray mica-schists which are presumably of the pre-Cambrian series. Thence to the south, about Trousers Lake, several knolls of serpentine occur. On the road from Bolton Centre to Grass Pond, or St. Etienne de Bolton, several prominent ridges and hills show along the east of the road. These are on range seven, Bolton, on lots seven to thirteen. At one place on lot eight, an attempt to mine asbestus was made, in 1889, without success, the veins being insignificant. The rocks associated with serpentine at this place are black slates, but directly to the west, chloritic and micaceous schists come in. This serpentine appears to be greatly shattered and is frequently slaty in structure, with a rich oily green aspect, unlike that of Thetford but similar to much of that about Orford Pond and the north side of Orford Mountain. The observed serpentine knolls are all to the east of the Grass Pond road, along which the mica-schist series is strongly

Bolton.

Asbestus mine.

developed, and thence to the west as far south as lot fifteen, range seven, where the gray and black slates and quartzites of the Cambrian appear and extend thence by the road south to Bolton Centre and beyond.

To the south of Orford Pond, a mass of serpentine comes to the shore, and has been cut through by the old Waterloo and Magog railway, now abandoned. Heavy masses of diorite, of the Orford Mountain chain, occur on both sides of the Pond, and the serpentine appears in masses on the road to Bolton Forest along with purple, black and greenish-gray slates. Near Bolton Forest post-office, these green slates become much twisted, schistose and even micaceous, resembling, in this respect, the pre-Cambrian schists. They are cut by granitoid and dioritic masses on the line of the Canadian Pacific railway to the north. West of Bolton Forest, the black pyritous slates and grits of the Cambrian again show, as far as Missisquoi River. These have been described in connection with the serpentine of that district, and it is probable that the schistosity at this place is due to a local alteration.

Serpentine of Melbourne and Cleveland.

New Rockland slate quarries.

The only other areas of serpentine which require brief notice here, are found in connection with the slates of the Melbourne and Cleveland district, and may be called locally the St. Francis River area. At the New Rockland quarries, and at the Melbourne quarry as well, the rock to the west of the principal slate belt is serpentine. This belt forms hills in the vicinity, to the east of the narrow gauge railway, which connects the slate quarry with the Grand Trunk railway, and the rock crosses to the road which runs up the south side of the St. Francis, about three miles and a half south-east of Richmond. In this serpentine, small veins of asbestus have been observed, some of which hold fibre of over half an inch in length, but the quantity is so small that the extraction is not profitable. Crossing the St. Francis, the extension of this band of serpentine is seen on the east side of the river, near Bedard's slate quarry, and here, also, veins of asbestus are visible. It also crops out in occasional masses through the belt of hilly and wooded country between this place and the Shipton Pinnacle, and several attempts have been made to open profitable mines in this section, but hitherto without success. These mining locations are about three-eighths of a mile south of the road going east from St. Cyr's crossing, on lot nine, range nine, Cleveland. The veins of asbestus here are small and irregular, varying from mere threads up to three-eighths of an inch in width, but the fibre lacks continuity and is of little value. The rock is sometimes black and cherty, at others green, or mottled yellowish-green, and at others again greasy looking, like the rock of Bolton. Here the slates associated are the black

Bedard's slate quarry.

Mining areas in Cleveland.

greenish-gray and purple varieties of the Cambrian, while the ridge to the west is composed of schists, possibly of pre-Cambrian age. The same relations are seen in the serpentine of Melbourne, the slates of the quarry being of Cambrian age, while the schists, &c., to the west belong to the Sutton Mountain anticline.

Areas south of Windsor Mills.

The areas south of Windsor Mills, on lots seven and eight, ranges four and five, Brompton, are probably the most northerly outcrops of the Brompton Lake serpentine belt. In this also the indications for asbestus appeared to be very small, and no veins were seen. The delimitation of the serpentines and diorites of this belt, west and north of Memphremagog Lake, is almost impossible. This country is very rough and hilly, largely forest-covered, except along roads and lakes. Small outcrops of slates and sandstones occur here and there, but frequently the rock between the hill outcrops is concealed by drift. While the indications, as far as seen, are not favourable to the occurrence of asbestus in workable quantity, chromic iron is known to exist at several points and may be found at some time in greater profusion, as in the case of the recent discoveries in the Black Lake and Coleraine districts to the north-east.

Surface Geology.

Marine shells.

The remarks on this subject contained in two preceding reports* are to a large extent applicable to the district covered by the present one. The great plain of the St. Lawrence, east of that river shows the presence of marine clays at many points, the fossils from which are the same as already described from the vicinity of Montreal. Among localities where marine shells are found, may be mentioned, the Grand Trunk railway, one mile east of St. Liboire station, and lot twenty, range six, Stanbridge, where in digging a large ditch a great quantity of shells have been thrown out. The covering of clay and sand drift appears to be of great thickness throughout this area, and has been already well described in the Geology of Canada (p. 925). The marks of ice action are quite numerous where ledges are well exposed, more particularly between the lower end of Memphremagog Lake and the St. Francis River, and to the west of the Sutton Mountain range. At the foot of the lake just mentioned, the course of the striæ is north, tending to N. 20° W. on the Montreal road, south of Brompton Lake, and about Lake Webster. In North Stukely and in Ely, the general course of the striæ, on the west side of the high ridge is

Striæ.

*Annual Reports, Geol. Surv. Can., 1886, vol. II. (N.S.), p. 44 J; 1887-88. vol. III. (N.S.) p. 98 K.

north-west, parallel with the valley of the St. Francis River. Along the course of this stream, the striæ, where exposed, have a similar direction, showing that the local glaciation followed this depression. That this ice-movement was to the north-west instead of south-east, is seen by the presence of large loose masses of serpentine and dioritic rocks probably from the Orford Mountain range, one large mass weighing not far from 1000 tons being seen on lot twenty-seven, range nine, of Stukely, at some distance north-west (or in the direction of the striæ in the vicinity) from the masses of serpentine about Long Lake, from which it was presumably derived. Where the brook valleys have much depth, the course of the striæ changes to follow these, and this is well seen in the tributaries of the St. Francis, on the north, and of the Missisquoi on the south. Along the latter river, the striæ closely follow the course of the depression through the gap in Sutton and Potton. This appears to confirm the conclusions stated in 1886, that the traces of glaciation observed at the present day are purely of a local character, and that if a continental ice-sheet ever prevailed over this portion of Canada, its traces have long since been removed.

Travelled blocks.

Striæ follow local depressions.

Denudation of Silurian formations.

The enormous denudation to which this area has been exposed, has been briefly alluded to in earlier reports,* and may be seen in the fact that outlying patches of lower Devonian rocks, of very limited extent, occur on the Chaudière River and further north in the township of Langevin, as well as on the shore of Memphremagog Lake, 100 miles to the south-west, being presumably the remains of a wide-spread Devonian area which, in connection with the numerous widely scattered outliers of the Silurian fossiliferous sediments, extended over the greater part of eastern Quebec. The study of the surface geology of this area has recently been taken up by Mr. R. Chalmers of this Survey, whose investigations will doubtless furnish us with much valuable information bearing on the question of the ice-movements and the direction from which the drift was derived.

Economic Minerals.

Little remains to be said on this subject in addition to what is given in the report lately published on "The Mineral Resources of Quebec."† The principal mining industries are confined to asbestus, copper and slate, and of these the more important operations are carried on in areas described in former reports and not in that covered by the present.

* Geology of Canada, 1863, p. 669; Annual Report, Geol. Surv. Can., 1886, vol. II. (N.S.), 23 J.

† Annual Report, Geol. Surv. Can., 1888-89, vol. IV. (N.S.), part K.

Asbestus.—Several attempts have been made to find asbestus in workable quantities in the southern belt of serpentine, but hitherto without success. Among the places examined may be mentioned, the Montreal road, a short distance west of Long Lake, where a single "gash" vein with fibre of a little more than a fourth of an inch in length was disclosed in a cutting by the roadside. This was apparently the only indication of asbestus at this point. Second, near the shore of Orford Pond, in similar small veins of no economic importance. Third, on lot eight, range seven, Bolton, where two openings were made but very little asbestus was seen at either; small veins, of a fourth of an inch in the widest part and running from two to three feet in length, were found, but nothing of size sufficient to warrant further search. Fourth, on the road from Knowlton Landing to Rexford Corner on lot twenty-eight, range seven, Bolton, where the indications are equally unfavourable. Fifth, the Brompton Lake mine, on lot twenty-six, range nine, of Brompton. This locality was visited twice; on the first occasion before the commencement of operation by the present company and later during the season of 1890 after the expenditure of a large amount of money on the property. Special interest attached to this place from the fact that it represented the most southerly of the large supposed asbestus-producing areas, and promised useful information as to the probability of the serpentine masses of the southern belt containing asbestus in profitable quantity.

Asbestus, Long Lake.

Bolton.

Brompton Lake mine.

The serpentine of this locality is of the hard compact variety and shows the presence of two kinds of asbestus, the one a black stiff fibre from a fourth of a inch to nearly or quite an inch in length, in places several of these small veins being close together. This fibre, from its harshness, is unfitted for spinning or felting and is, in so far as yet known, of but small value. The second variety of asbestus is found in small veins of a fourth to half an inch, of soft whitish-green fibre with but little elasticity or tenacity, the containing rock being a hard blackish-green serpentine, in places passing into the variety known as diallage. The indications seen at that time were regarded as very unfavourable for successful mining. Three pits were opened up by the company, situated on two knolls, of which the southern contains two pits and the northern one. At the principal pit, the clay covering is very heavy and the indications noted in the first visit are borne out by the absence of workable veins of asbestus in any of these. It is not yet known that any asbestus of value has been obtained here.

The new mining areas north of the St. Francis have already been referred to. A good deal of money has been spent in exploratory work,

but the quantity of asbestus so far found is small and confined to small veins of short fibre.

Lake Memphremagog Mining Co.

Copper.—The Lake Memphremagog Mining Company, after spending a considerable sum in development work, has closed down the mine at the Hog's Back Mountain for the present, owing apparently to a lack of profitable market for their ore. This is a pyrrhotite already described in the "Mineral Resources of Quebec," and no further details can here be given of this property.

Huntingdon mine.

The old Huntington mine was pumped out during the autumn of 1890, by Messrs. G. H. Nichols & Co. and some further underground exploratory work carried on in the vein of ore, but no details have been received as to the amount of work done or results obtained.

Iron ore locations.

Iron ore.—The localities in which iron ore occur have been described in "The Mineral Resources of Quebec."* They may, however, be briefly enumerated here. On the west half of lot forty-five, west St. Armand, red hæmatite and specular schist. Iron ore also occurs on lots five and seven and north half of lot nine, range nine, and lot nine, range seven, Sutton; on lots one and two, range three; lot five, range four, and on lots four, five and six, ranges three and four of Brome; on lot two, range fourteen, Bolton, and on lots twenty-one and twenty-two, range fifteen, Orford. The ore in the above-mentioned localities is sometimes magnetic, at others specular, and in places contains a very considerable proportion of titanic acid, reaching sometimes as much as twenty-eight per cent. A deposit of iron pyrites (pyrrhotite) occurs on lot twenty-eight, range nine, Potton, overlain by a deposit of bog-iron ore from one to three feet thick. This is on the west side of the Hog's Back Mountain.

Bog-iron ore.

Chromic iron.

Chromic iron, is reported as occurring on lot twenty-six, range seven of Bolton, and assays have shown the deposit to be sufficiently rich in chromic oxide for shipment. Loose pieces have also been picked up on the west side of Memphremagog Lake, where the serpentines are particularly developed, which have shown a very large percentage of chromic oxide. There is therefore a strong probability that workable deposits of chromic iron will some day be found in some portion of this serpentine belt.

Anorthosite.

Building materials.—The anorthosite rocks of the St. Jérome and New Glasgow areas, are in places largely quarried for paving blocks, for which purpose their toughness renders them well fitted. They are used in Montreal, as also are blocks from the syenite rocks of Yamaska Mountain taken from a quarry on the north-west flank. Similar rock is quarried largely in the Shefford Mountain and used for building

* Annual Report, Geol. Surv. Can., vol. IV., 1888-89.

purposes. A quarry in nepheline syenite, on the west side of the Montreal Mountain, has also been worked for some years for road metal.

The Potsdam sandstone, which is so largely developed near the New York boundary between Huntingdon and Hemmingford, as well as along the St. Lawrence and the lower Ottawa, forms an excellent building material, and is used to some extent in Montreal. The Parliament and Departmental buildings at Ottawa are largely constructed from the stone of this formation. Certain portions of the sandstone, free from iron, are said to be well adapted, when crushed, for glass making, as in the rock from Williamstown and from certain beds in Vaudreuil, and it has also been found suited for hearths and linings of blast-furnaces. The sandstones of the Sillery formation near Granby are also well suited for building stone, and in Quebec many of the large buildings as well as the city wall are constructed from a similar stone found in the vicinity of the city. Potsdam sandstone.

The crystalline limestone of Phillipsburg, has already been referred to as furnishing an excellent material for construction and for decorative purposes, and has been somewhat extensively quarried ; while the excellence of the limestones of the Trenton, Chazy and Black River formations as developed on the islands of Montreal and Jésus has long been recognized. Extensive quarries in the limestones exist at various places, such as Mile End near Montreal, Côte St. Michel, several points along the Back River, St. Martin's Junction, &c. Phillipsburg limestone.

The Silurian and Devonian formations of Memphremagog Lake furnish certain flaggy beds which split out readily and have been used for pavements and flagging generally, being apparently well suited to this purpose. Memphremagog slates and flags.

The syenitic rocks of Yamaska and Brome mountains have been quarried to some extent ; that of the former for paving blocks and the latter for building stone, for which purpose it appears well adapted. Yamaska and Brome Mountain syenitic rock. Quarries in the Chazy limestones of St. Dominique, are also in operation, and considerable quantities of apparently excellent building stone are being shipped from this place. The two principal quarries operating here, in 1890, were owned by the Grand Trunk railway and by Mr. T. H. Howley. The latter, in 1889, put out, with twenty-five men, about 800 yards of dressed stone. The output from the Grand Trunk quarry is probably about the same. St. Dominique limestone.

At South Stukely, quarries exist which furnish a crystalline limestone, suitable for building stones, of good quality, from which the church at North Stukely was built and at which also the rock is quarried for South Stukely limestone.

lime burning by Mr. Goddard, of South Stukely. This is on lot eight, range two, of that place. Mr. Lachance, of Ste. Anne de Rochelle, also burns lime from the crystalline limestones found on the road on lot thirteen, range seven, North Stukely.

New Rockland slate quarry.

The slate industry of New Rockland is being pushed with the usual vigour, a valuable new bench of slates being reported from the eastern side of the quarry, so that the work will be extended at the surface instead of sinking to a greater depth. The new red or purple slate quarry of Jenkins and Davis in Brompton Gore, was worked to some extent during the season of 1891, but was hindered by the lack of facilities for shipment. The slate appears to be of excellent quality. A deposit of slate on lots four and five, range three, of Brome, owned by Call Bros., shows smooth greenish slates, in the stream below the woollen mill on the south branch of the Yamaska River. These are fissile, but in places are cut by irregular bunches and veins of quartz. They dip north-westerly $< 85°$, and are associated with the green chloritic schists of the Brome area. Ledges of similar slates occur in the woods near the road leading to Sweetsburg, about three-eighths of a mile west of this stream. These slates are probably in the lowest part of the Cambrian series.

Brompton Gore quarry.

Slates of Brome.

Rankin Hill, &c.

Several of the slate quarries, as at Rankin Hill, east of Actonvale, Kingsey near the St. Francis River, Mawcook between Granby and Abbottsford, in all which the rock is reddish and purple, have been for various reasons abandoned. The old Melbourne or Walton quarry, to the north-east of the present New Rockland quarry, in grayish slates, has also been closed for some years.

Lime-kilns.

Lime-kilns are found in the Papineau range south of Yamaska Mountain, where the dark limestone of the Trenton occurs, and in the Casimir range, L'Ange Gardien, several miles further south, in similar lime rocks.

The rock of the quarries in Montreal Island and on Isle Jésus, as well as St. Dominique have long been utilized for this purpose. The stone used is principally Trenton or Black River and the kilns produce annually a very large quantity of excellent lime.

Brick clays.

The marine clays of the St. Lawrence Valley, furnish excellent material for brick making, and several yards are in operation. Extensive works are found about Montreal, St. Johns, and on the road between Actonvale and Roxton Falls, as also on the road north of Richmond, about half a mile east of the town. Other local kilns have been in operation of which we have no present returns.

At Laprairie, opposite Montreal, the Laprairie Pressed Brick and Terra Cotta Company, make use of the crushed shale of the Utica formation, and turn out a large amount of excellent bricks. The crushed slate of the Rockland quarry should also make an excellent material for this purpose, and proposals were made several years ago to establish works of this nature in the vicinity. The scheme has, however, apparently been abandoned for the present. Utica shale.

Peat.—Large areas of excellent peat occur in several places, and some of these have been extensively worked. The largest and most easily accessible deposits are probably those on the line of the Canadian Pacific railway at Ste. Brigide, between St. Johns and Farnham, and in the vicinity of the St. Lawrence, near Valleyfield and Beauharnois as well as in Huntingdon. The works at Ste. Brigide and at Port Lewis in Huntingdon, have been closed for some years, but new processes of manufacturing compressed peat may cause these deposits to be again utilized at no distant day. The upper portion of these bogs should furnish an unlimited supply of material for the manufacture of moss litter, now rapidly coming into use, and for which there promises to be a very considerable demand. Peat deposits. Moss-litter.

Shell marl, is found in the Seigniory of St. Hyacinthe, near the foot of Yamaska Mountain, and near the road to Granby and St. Pie, in a deposit one foot thick, extending over several acres and covered by a thin layer of peat. It is also reported from lots one hundred and fifty-seven and one hundred and fifty-eight St. Armand, in a deposit covering thirty to forty acres and having a depth of seven feet in places. In Stanstead also, on lots four and five, ranges ten and eleven, it is said to cover an area of twenty acres near the shore of a small lake and to have a depth of thirty to forty feet. Marl also occurs in the Seigniory of Vaudreuil, at Pointe à Cavagnol, as well as on the Island of Montreal between Montreal and Lachine and at Thornberry on the west side of Mount Royal. Shell marl.

Soapstone, is said to occur in the township of Potton on lot twenty-four, range six, and on lot twenty, range five, the band being about three feet thick. It is found also in Bolton, lot twenty-four, range six and on lot sixteen, range five, and lot seventeen, range nine, associated with magnesite. It is also reported on lot four, range four; and in Sutton on lot twelve, range seven. A band of impure soapstone is also seen in a cutting on the Canadian Pacific railway, a short distance west of Orford Pond. Soapstone.

Potstone, occurs in a bed, twenty feet thick on lot twenty-six, range two, Bolton, and also on lot twenty-six, range six of Potton. Potstone.

Whetstone.

Whetstone.—Bands of rock well suited for the manufacture of whetstones and formerly worked, occur on Whetstone Island, Memphremagog Lake, on lot four, range nine, Stanstead; near the upper end of Massawippi Lake on the west side; on lot twenty-three, range six, Bolton; on lot seven, range two, Kingsey, and on lot nine, range eighteen, Orford. Certain bands of mica-schist, associated with the rocks of the Sutton Mountain anticline, should also be adapted to the manufacture of scythe-stones.

Mineral waters.

Mineral Springs.—A "sulphur spring" occurs at Bolton, near the Missisquoi River, about four miles west of Knowlton Landing, and a hotel for invalids was erected at this place several years ago. Springs also occur at Sabrevois, near Pike River village, one of which contains salts of strontia and baryta, while another holds soluble sulphates. Somewhat important springs are also found at St. Hyacinthe, St. Benoit, St. Eustache, Ste. Martine, Beauharnois, &c. These have been described in the Geology of Canada, pp. 542-44.

LAURENTIAN AREA IN NORTH-WEST CORNER OF THE SHEET.

By F. D. Adams, Ma.Sc., Ph.D.

GENERAL STATEMENT.

Laurentian protaxis.

The continent of North America, as is well known, has been gradually built up by an accumulation of sediment about certain very ancient land areas which are known as its protaxes. Of these the largest and most important is the great northern protaxis, which forms the greater part of northern Canada, having an area of somewhat over 2,000,000 square miles and constituting what Suess has termed the Canadian shield or boss.

The Laurentian area which forms the extreme north-west corner of the sheet at present under discussion, is a portion of the southern margin of this great northern protaxis and thus represents a part of an extremly ancient land area, from the waste of which the clastic Palæozoic strata to the south were derived.

The area of these ancient rocks embraced in the sheet is small, amounting to about 400 square miles; it forms, however, part of a much larger district, stretching to the north beyond the limits of this map, the geology of which has been worked out, and a map of which, with full explanatory report, will appear shortly. In the following pages, therefore, merely a brief general description of that portion of this district lying within the limits of the map accompanying the present report will be given, leaving the more detailed discussion of the district as a whole, and the many problems which it presents, for the fuller report which will appear later.

Character of country.

In the aspects of its relief, this Laurentian country is sharply marked off from the plains, underlain by the Palæozoic—which bound it on the south. It is a somewhat uneven plateau, the edge of which when viewed from the plains appears as a range of hills running in a north-east and south-west direction. The plateau slopes gently to the south-east from an average elevation of about 1000 feet above sea-level at the north-west corner of the map, to about 450 feet above sea-level along the edge of the plain.

The depressions in its surface are generally filled with drift, forming extensive flats, in which are many picturesque lakes of clear water

the largest being Lake L'Achigan in the township of Kilkenny. Four rivers also cross it, namely the North River, the River L'Achigan, the Saint Esprit and the Lac Ouareau River.

The landscape of this Laurentian country is of a pronounced type which, while lacking on one hand the grandeur and sublimity of high mountain regions and on the other the tranquil beauty of the well cultivated lowlands, has a certain rugged beauty of its own, especially when clothed with the brightly coloured foliage of autumn.

The area is about equally divided between the rocks of the Laurentian system and intrusions of anorthosite which break through these.

The Laurentian consists of red and gray orthoclase gneisses, presenting great variations both in structure and composition, with which are associated crystalline limestones, quartzites and amphibolites. These rocks often occur in the form of bands or beds alternating with one another, but in some places the banding is replaced by a more or less distinct foliation due to a parallel arrangement of the individual grains of the various constituents which go to make up the rock. Both structures are often found in the same rock, and when thus occurring together they coincide in direction. In order that a purely objective attitude may be preserved, the term band, rather than bed, is employed in the present report, the latter term being usually associated with the idea of a sedimentary origin, which, however probable, for certain parts at least, of the present district, cannot be considered by any means as demonstrated for the system as a whole.

Two divisions.

In many other parts of the Laurentian, two divisions can be recognized in the system, namely, an upper series characterized by the presence of crystalline limestones, quartzites and gneisses, having the chemical composition of ordinary sediments as well as a preponderating banded structure, which is called the Grenville series, from a township of that name in the County of Argenteuil where it is well developed, and a lower series of gneisses much more monotonous and uniform in character, in which are no limestones, &c., and which possess a foliated rather than a banded structure. This latter series is known as the Fundamental Gneiss, and in many cases closely resembles igneous rocks.

Grenville series.

In the area at present under discussion the two series cannot be so clearly distinguished. Certain parts of the area can be recognized as belonging to the Grenville series, as, for instance, the extreme easterly portion lying to the south of Rawdon and the westerly portion in the St. Sauveur district. Other portions, as much of the St. Jérome

district, has the appearance rather of the Fundamental Gneiss. It has been found impossible, however, to separate the two series and delimit them on the map. Fundamental Gneiss.

Breaking through the gneisses are four masses of anorthosite, an intrusive rock belonging to the gabbro class, but characterized by a great preponderance of plagioclase felspar. Of these the two largest, comprising portions of the townships of Abercrombie and Kilkenny respectively, are really portions of a single very large area, which extends to the north-west beyond the limits of the map, and has a total area of about 1000 square miles. This is known as the Morin anorthosite area, and is rudely circular in shape. The anorthosite occurring in the north-west corner of the present sheet, including the township of Abercrombie, is a portion of the southern extension of the mass, while the anorthosite in the Kilkenny district is the extremity of a large spur, which starting from the eastern side of the mass runs south, following the strike of the gneiss, and finally passes beneath the flat-lying Palæozoic strata of the plains, being at its southern extremity split in two longitudinally by a wedge of gneiss which runs up into it.

Six miles to the north of the limit of the present sheet, these two masses of anorthosite come together and pass into one another, and they will, therefore, be treated of as one and the same mass, which they really are. Anorthosite.

The other two areas, situated about St. Jérome and in the Gore of Chatham respectively, are much smaller and less important.

These anorthosite masses are now known to be intrusive. Owing to the fact that in some places they possess a more or less distinct foliation coinciding with that of the gneiss through which they cut, Logan and the other early Canadian geologists who first examined the area, thought that they, together with a portion of the associated gneisses and crystalline limestones, formed a series of stratified rocks distinct from and reposing upon the Grenville series. This supposed upper series was, therefore, termed the Upper Laurentian, and the anorthosites were considered to be its most characteristic members. The name Norian was also proposed by Sterry Hunt for these rocks, owing to their petrographical resemblance to the norites of Scandinavia, which rocks are now also recognized as intrusive. Although intruded through the Laurentian at a time long preceding the Potsdam, the appearance of these anorthosites antedated at least the termination of the great earth movements which affected the Laurentian in pre-Potsdam times, so that they have been squeezed and foliated together with the gneisses through which they cut.

Overlain by the Palæozoic.

On the upturned edges of these deeply eroded Archæan rocks, both gneiss and anorthosite, the Potsdam sandstone and other Cambro-Silurian rocks repose in flat and undisturbed beds. At some points along the edge of the protaxis, as at St. Canut, to the west of St. Jérome, the Potsdam sandstone is observed resting upon the gneiss ; but as the plains are for the most part mantled with drift the actual contact is not in all cases seen, so that the Palæozoic exposures nearest to the Laurentian, in some places consist of the magnesian limestone of the Calciferous, as to the south of St. Jérome, or even of the Trenton limestone, as between New Glasgow and Ste. Julienne.

A small outlier of these Palæozoic rocks occurs on the third and fourth ranges of the township of Abercrombie, about nine miles north of the edge of the protaxis, and proves that the Palæozoic strata once extended considerably further to the north than they do at present, although this outlier probably does not by any means mark their northerly limit.

The Palæozoic strata cover up the gneisses and anorthosites alike, and are evidently of much more recent age, being separated from the Laurentian by the long interval occupied in the upheaval and erosion of the Laurentian area. How long before Upper Cambrian times this folding and erosion took place cannot be determined from a study of this area, but investigations in other portions of the margin of the protaxis makes it very probable it took place in pre-Cambrian times.

THE LAURENTIAN PROPER.

This great system consists, as has been stated above, of orthoclase gneiss, presenting many varieties both in form and composition, alternating and interbanded with plagioclase gneisses, crystalline limestone, quartzite, amphibolite and other crystalline rocks.

Gneiss.

These rocks present many transitional forms. Thus bands of quartzite, holding more or less orthoclase, represent varieties intermediate between true quartzites and quartzose gneisses. Crystalline limestones, again, in certain places become very impure, owing to the presence of grains of various silicates, and may thus be classed as calcareous gneisses.

Orthoclase gneiss preponderates largely, and would, if the crystalline schists were classified in the same detail as the intrusive rocks, be separated, owing to variations in its composition, into a number of varieties, equivalent respectively to the various orthoclastic intrusive rocks, as well as the various transitional members between these

and the plagioclase rocks of the diorite and gabbro families. A common characteristic of all these orthoclase gneisses is the presence of a banding or foliation which may be and often is as well pronounced as the lamination of any sedimentary rock, but which, on the other hand, in some cases is so indistinct that it can only be detected by the examination of large weathered surfaces. Some of the gneisses are highly acid, consisting essentially of quartz and orthoclase feldspar. Most of them, however, contain in addition a considerable quantity of biotite or hornblende, while others, owing to the presence of a considerable proportion of plagioclase as well as of hornblende or pyroxene, with a corresponding diminution in the amount of quartz present, are properly classed as basic gneisses.

Many of the basic gneisses are closely related to and associated with the anorthosite masses. Some probably of igneous origin.

Many of these gneisses differ in no way in composition from igneous rocks. This is especially true of those which from their uniform character and absence of all associated limestones, quartzites, etc., are referable to the Fundamental Gneiss rather than to the Grenville series, although many gneisses in the Grenville series belong to this class as well. These gneisses usually show in a marked manner what is known as a cataclastic structure, produced by the mechanical breaking down of the original web of the crystalline rock, by movements induced by great pressure, which movements cause in the rock a foliation or parallel arrangement of constituents more or less distinct, according to their intensity. In this way a coarse-grained granite may be converted first into an augen-gneiss, and finally into a very finely foliated gneiss in which all the original quartz grains have the form of thin leaves. This structure is also remarkably well seen in the anorthosite, in most places where it occurs in this area, and will be more particularly described in treating of this rock. Many of these gneisses, at least, were originally of igneous, probably of intrusive, origin. Examples of these are abundant in that part of the area lying between St. Columban and St. Jérome and between this latter place and Ste. Sophie.

In order to ascertain the chemical composition of a typical gneiss of this class, Logan's typical Fundamental Gneiss from Trembling Mountain was selected. An analysis of it is given under No. 1.

Analysis.

	I. Gneiss. Trembling Mt.	II. Granite. Carlingford.
Silica	69.24	70·48
Alumina	14·85	14·24
Ferric oxide	2·62	3·72
Manganous oxide	·45	
Lime	2·10	1·48
Magnesia	·97	·40
Soda	4·30	3·66
Potassa	4.33	4·26
Loss on ignition	·70	1·59
	99.56	99·83
Total alkalies	8·63	7·92

It forms almost the entire mass of Trembling Mountain, a long ridge rising on the east side of Trembling Lake to a height of 2500 feet and forming the highest point in the Laurentians of this part of Canada. The mountain does not occur within the area embraced by the present sheet, but lies about twenty miles to the north-west of its north-western corner. The rock, however, resembles closely that occurring at a number of points in the Laurentian area of this sheet. It is rather a fine-grained gneiss, uniform in character and is under the microscope plainly seen to be a crushed or granulated hornblende granite. The analysis shows it to possess a chemical composition quite different from that of the other gneisses and slates described below. The silica is high but the alumina comparatively low. The alkalies are also high, while the lime preponderates largely over the magnesia.

The composition is that of an ordinary granite. The analysis of a granite from the Carlingford District in Ireland, by Haughton, given under No. II., will serve to emphasize this identity.

The composition of most, if not all the gneisses belonging to the lower or Fundamental Gneiss, could be paralleled among the true igneous rocks.

Others probably of sedimentary origin.

The greatest variety in character is found among the gneisses occurring in the vicinity of the limestone bands. Here the gneisses are usually garnetiferous and often contain sillimanite, graphite, rutile, pyrite, and other accessory minerals, the last mentioned mineral when present causing the rock to weather in a very rusty manner. These rusty gneisses are not found except in association with the limestone bands and it is the exception to find the limestone unaccompanied by them.

Owing to the peculiar character of these several gneisses and their continuous association with the limestones and with bands of quartzite, which rocks are certainly not of igneous origin, but are met with in all highly metamorphosed sedimentary series, it was believed that some evidence might be obtained, pointing to a sedimentary origin in the case of these gneisses also. A large number of them were therefore carefully examined.

Under the microscope these do not show the cataclastic structure usually presented by the crushed and granulated igneous rocks of the system. They seem to have recrystallized under the influence of the pressure which has served to crush these other rocks. They are, however, now completely crystalline, no clastic material can be detected in them, although the character and arrangement of the constituent minerals is often suggestive of the metamorphosed rocks found in granite contact zones. The quartzites also, which are very frequently associated with these gneisses and which seldom occur elsewhere, do not, under the microscope, afford anything which could be taken as conclusive evidence of a clastic origin.

Important evidence, however, bearing on their origin was obtained from a study of their chemical composition. Four typical representatives of these gneisses were selected and analysed.

Evidence from chemical composition.

The analyses are given in the accompanying tables, together with analyses of three slates for purposes of comparison. Only one of these gneisses, No. V., is taken from the Laurentian area actually embraced in this sheet, the others however come from the continuation of this area immediately to the north. Analyses Nos. II., V., VII. and VIII. were made for me by Mr. Walter C. Adams, and analysis No. I. was made by Mr. Nevil Norton Evans, Lecturer in Chemistry in McGill University. To both gentlemen I desire to acknowledge my great indebtedness.

I. Gneiss from St. Jean de Matha, province of Quebec. A fine-grained garnetiferous sillimanite-gneiss, containing also much quartz and orthoclase. Graphite and pyrite are also present, the latter causing the gneiss to weather to a very rusty colour. It occurs in thick bands interstratified with white garnetiferous quartzite, the whole lying nearly flat.

II. Gneiss from the west shore of Trembling Lake, province of Quebec. A fine-grained dark-gray gneiss composed of quartz and orthoclase with much biotite, and containing little white streaks which were evidently at one time continuous little bands. These are composed of sillimanite. Garnets appear here and there in

the darker portion of the rock. It occurs near a band of crystalline limestone which occupies the bed of Trembling Lake.

III. An ordinary roofing slate from Wales. Analysed by T. Sterry Hunt. (Phil. Mag., 1854, p. 237.)

IV. A similar roofing slate of Cambrian age, from the large quarries in the township of Melbourne, in the southern portion of the province of Quebec. Analysed by T. Sterry Hunt. (Geology of Canada, 1863, p. 600.)

V. Gneiss from Darwin's Falls near the village of Rawdon, range V. of the township of Rawdon, province of Quebec. It is a highly quartzose garnetiferous gneiss and occurs in well-defined bands interstratified with quartzite, which is often highly garnetiferous, the bands being from a few inches to several feet in thickness.

VI. Red slate from near Tinzen in the district north of the Engadine, Switzerland. Highly siliceous, containing 9·12 per cent of silica as quartz. (Vom Rath, Z. d. G. G., 1857, p. 242.)

VII. Gneiss, lot 20, range VII. of the township of Rawdon. Gneiss composed essentially of malacolite, scapolite and orthoclase, and holding a considerable amount of graphite and of pyrite. Weathers very rusty. Occurs in well-defined bands, interstratified with a grayish-weathering garnetiferous gneiss.

Microscopical structure.

The four gneisses I., II., V. and VII., show no cataclastic structure, but when examined with a microscope seem to have undergone complete recrystallization under the pressure to which they have been subjected, no signs of crushing being now visible in the thin sections.

The analyses show that the first three of these gneisses have the composition of slates. Nos. I. and II. have the composition of ordinary roofing slate, as will be seen by comparing these analyses with analyses III. and IV., and are quite different in composition from any igneous rock. The high content in alumina, the low percentage of alkalies and the great preponderance of magnesia over lime, characteristic of slates will be noted.

No. V. is a gneiss which is so highly quartzose that it might almost be termed an impure quartzite, and also has a composition differing from that of any igneous rock, but one which is identical with many highly siliceous slates. No. VI. is such a slate from the Engadine district in Switzerland, and is, as will be seen, almost identical in composition with No. V. Siliceous bands from the Canadian slate quarries also have a similar composition. The alumina here is low on account of the preponderance of quartz, which also lowers the con-

tent of alkalies. The magnesia preponderates over the lime as before. No. VI. lost 1·92 per cent on ignition before analysis, and these figures do not therefore appear in the analysis as given above.

Analysis of sedimentary gneisses.

	I. GNEISS. — St. Jean de M.	II. GNEISS. — Trembling Lake.	III. SLATE. — Wales.	IV. SLATE. — Melbourne.	V. GNEISS. — Rawdon.	VI. SLATE. — Tinzen.	VII. GNEISS. — Rawdon.
Silica	61·96	57·66	60·50	64·20	74·70	79·97	54·89
Titanic oxide	1·66	....	....	....	....	....	1·66
Alumina	19·73	22·83	19·70	16·80	8·88	8·62	13·67
Ferric oxide.	....	....	....	....	9·64	6·63	1·35
Ferrous oxide	4·60	7·74	7·83	4·23	....	....	....
F'ric sulphide	4·33	....	....	....	....	....	4·43
M'n'ous oxide	trace.	trace.	trace.	....	·50	....	·62
Lime........	·35	1·16	1·12	·73	1·07	·76	5·63
Magnesia....	1·81	3·56	2·20	3·94	1·87	1·52	4·70
Soda...	·79	·60	2·20	3·07	·42	·64	1·95
Potassa	2·50	5·72	3·18	3·26	·95	2·30	8·34
Loss on ignit.	1·82*	1·50	3·30	3·42	1·05	....	(2·76†)
	99·55	100·77	100·03	99·65	99·08	100·44	100·00
Total alkalies	3·29	6·32	5·38	6.33	1·37	2·94	10·29

The fourth of these gneisses, No. VII., differs entirely from the others. The low content of alumina, combined with low silica, the high alkalies and the preponderance of lime over magnesia mark it off as quite distinct from the slates and gneisses just considered. If it be an altered sediment it is one which has suffered very little leaching during deposition, and must have been of the nature of a tuffaceous deposit, or one formed from the rapid disintegration of an igneous rock having the composition of a basic trachyte or syenite. It is, therefore, a rock which, so far as its composition is concerned, might be either an altered sediment or an altered igneous rock ; and it is impossible, consequently, to draw from its chemical composition any definite conclusions as to its origin.

In the case of those gneisses, then (Nos. I., II., V. and VII.,) whose stratigraphical relations and microscopical character suggest a sedimentary origin, the first three have the composition of slates, that is to say, of clay ; in the case of No. V., of clay mixed with sand, while in the case of No.VII., no definite conclusion can be drawn. To sum up, therefore, it may be said concerning the gneisses of this class, that : (1) their association with numerous and heavy beds of limestone and quartzite ; (2) their prevailing banded character, accompanied by a

*Water.
†Water and graphite (by difference.)

very extensive recrystallization ; (3) the frequent occurrence of graphite in all rocks of the class, and (4) the fact that the gneisses of this class have in many cases at least the composition not of igneous rocks but of sands and muds—combine to make it extremely probable that we have, in the case of many of these rocks at least, extremely altered forms of very ancient sediments.

Quartzite. The quartzite occurs in well-defined bands, in the vicinity of the limestones. It is sometimes quite pure, consisting of translucent or transparent vitreous quartz, but frequently holds garnet, sillimanite or other minerals. It is well seen at Darwin's Falls and elsewhere, near the village of Rawdon, as well as all through the Laurentian district to the south of that place. Amphibolite is a common rock, occurring in association with the gneisses in all parts of the area, but usually in comparatively small amount. It is dark or nearly black in colour, and is seen under the microscope to be composed essentially of plagioclase felspar and dark-green hornblende. The latter mineral occasionally holds a core of pyroxene, suggesting that the rock was originally a gabbro or diabase.

Amphibolite. These amphibolites usually occur as bands in the gneiss and are not confined to the limestone districts, and where the gneiss can be seen to have been greatly stretched or rolled out under the influence of pressure, these amphibole bands can invariably be observed to have been pulled apart into separate pieces, showing that under such pressure they are less plastic than the orthoclase gneiss.

Limestone. The limestones are coarsely crystalline marbles, white or nearly so in colour, sometimes nearly pure, as in portions of the band near St. Sauveur or the occurrence on lot 10 of range VII., of Kilkenny ; but at other times very impure, as in much of the New Glasgow band, the impurities consisting of grains of quartz, pyroxene, phlogopite, graphite and other minerals disseminated through them. So much of this area is occupied by anorthosite intrusions, that the limestones are less abundant than usual in districts underlain by the Grenville series.

As these limestones, however, are important members of the series on account of genetic considerations, as well as owing to the light they throw on the stratigraphical relations of the series as a whole, the several occurrences will be specified.

St. Sauveur. Commencing on the west, there is limestone lying immediately to the west and north-west of the village of St. Sauveur. This is the most extensive development of Laurentian limestone in the area. It, for the most part, underlies a low, undulating drifted tract of country

and is associated with basic, often rusty-weathering gneisses. To the north it is cut off by the Morin anorthosite, whose southern limit here appears as a high and abrupt cliff crossing the country. The limestone has at several points been somewhat extensively quarried for the production of lime, having been burned at intervals for many years—the fact of its being a limestone having been pointed out to the inhabitants by Logan in the early years of the Geological Survey. It is stated to form a very strong lime, but one which from the presence of grains of various silicates disseminated through it, is more or less impure, and which is thus suitable for rough masonry work rather than for interior finishing.

Further south in the augmentation of Mille Isles, similar limestone occurs again, and was supposed by Logan to form a continuation of the same band as that exposed near St. Sauveur.

Another occurrence of limestone, which, however, is small and unimportant, is that on the west side of the North River near St. Jérome. It is seen crossing the road which runs down the west side of the river, a short distance from the town, while blocks of it may be observed at intervals in the fields to the south of the road. Further south, the strike would carry it across the North River where it would be covered up by the Palæozoic rocks. It does not appear, however, on the banks of the river, nor could any continuation of it be found to the north. St. Jérome.

A more important development of limestone, in the form of a band, which, although it can be traced several miles, is still comparatively thin and impure, is found a short distance to the west of the village of New Glasgow, being exposed in the bed of the River Jordan near the edge of the Palæozoic. From this point it can be traced in a direction a little east of north, skirting along the edge of the great anorthosite mass which occupies this part of the sheet, as far as the third range of Kilkenny, a distance of about six miles, where it is lost sight of. If it holds the course as above described, it would be cut off by the anorthosite a short distance to the north of the point where it is last exposed. New Glasgow.

An isolated occurrence of a fine white crystalline limestone is also found on lot 10 of range 7 of Kilkenny, where it forms a low ridge about 100 yards wide, running north-and-south. Kilkenny.

In the northern half of the township of Rawdon, beyond the limits of this map, there is a heavy band of crystalline limestone running through the township from north to south. The southern portion of the township where underlain by the limestone is, however, so heavily Rawdon.

drift-covered that but few exposures are to be seen. On the 4th range, along the road between the village of Rawdon and Ste. Julienne, a few small exposures of limestone protrude through the drift on lots 13 and 15, associated with quartzite and gneiss, which may be a continuation of this limestone to the south, and are so represented on the map. If so, the limestone band is greatly diminished in size to the south.

THE ANORTHOSITE INTRUSIONS.

As has been mentioned above, about one-half of the Laurentian corner of the sheet is occupied by intrusions of anorthosite. Four separate occurrences are represented on the map, but the two larger are really portions of the same intrusion, known as the Morin anorthosite mass, and unite to the north.

Anorthosite intrusions.

This anorthosite is a basic rock belonging to the family of the gabbros, but characterized by the great preponderance of one constituent, namely, the plagioclase felspar, which is so abundant that it often makes up the entire rock. The other constituents are monoclinic and rhombic pyroxenes and ilmenite. No olivine has been found in any of the areas on this sheet. The rock is usually coarse in grain, its structure being especially well seen on the large weathered roche moutonnée surfaces. In its normal condition the rock has a granitoid structure and is deep violet, almost black, on a fresh fracture. The anorthosite in that portion of the area occupying the extreme north-west corner of the sheet, in the townships of Morin and Wexford, as exposed along the road and railway between Ste. Adèle and Ste. Agathe, shows these characters. The same is true of much of the anorthosite beyond the limits of the sheet to the north. The rest of the Morin anorthosite embraced within the limits of the sheet, represents peripheral portions of the mass and consequently shows in a marked manner the effects of the great pressure to which the whole area was subjected before the deposition of the Potsdam. The first effect of this pressure is the production of a brecciated structure in the anorthosite, especially well seen on large weathered surfaces about Ste. Marguerite and elsewhere in the eastern part of the township of Wexford. This brecciated structure is produced by the partial granulation of the rock, the resulting rock consisting of fragments of plagioclase or of the other constituents of the rock, embedded in a species of groundmass made up of smaller grains derived from the breaking-down of the larger individuals. The brecciation being accompanied by a movement of the rock in some definite direction, develops a streaked or irregular banded structure. A very remarkable fact in connection with the

Morin anorthosite.

Effects of pressure.

development of this structure is that wherever the rock becomes granulated it becomes much lighter in colour. This can be observed even in microscopical sections, when the phenomena is seen to be due to the disappearance of the dark dust-like inclusions which give to the felspar its dark colour, wherever the mineral becomes broken up or granulated, and so uniformly are these two processes connected, that it is always possible to predict when examining a thin section under the microscope, just how much of the rock has been granulated by observing its colour, before using polarized light, by which the extent of the granulation is at once made visible. So common is the granulation throughout the area, that even in the most massive and granitoid specimens of the anorthosite, traces of it can usually be found.

When the effects of pressure are more marked, as close to the edge of the area or anywhere in the most easterly development of the anorthosite in the townships of Rawdon and Kilkenny, the granulation becomes much more pronounced and a progressively larger proportion of the rock becomes granulated. This is accompanied by the passage of the streaked structure into a distinct and often perfect foliation, which coincides with the foliation of the surrounding gneiss, and by a bleaching of the rock, until in the varieties showing an advanced stage of granulation only a few small dark remnants of the original coarsely crystalline plagioclase individuals remain, like augen in an augen-gneiss, embedded in a mass of finely granulated plagioclase, often so white that at a distance the rock cannot be distinguished from marble. This variety is well seen about New Glasgow, where it has been extensively quarried for paving stones which are used in Montreal. It is also well seen along the contact near the east end of Lake L'Achigan, gradually becoming dark in colour towards the west end of the lake about St. Hippolyte. Foliation eventually resulting.

The anorthosite undergoes no change in chemical composition during the granulation above described—the process, as studied under the microscope, appears to be a purely mechanical one. It is thus quite different from that commonly observed and which has been described by Lehman and others in the case of sheared gabbros. In all cases of shearing hitherto described, the pyroxenes under the influence of the pressure are altered to hornblende, while the plagioclase is often altered to saussurite, the resulting rock being an amphibolite not a gabbro. There is reason to believe that the movements which affected these anorthosites took place when the rock was deeply buried and probably also very hot, perhaps near its fusing point.

Contact rocks.

Although, in most places, the Morin anorthosite comes against the gneiss without producing any perceptible alteration, at some parts of its

circumference, especially north-east of Echo Lake, where the contact crosses the townships of Abercrombie and Kilkenny, a rather massive, dark, heavy rock, rich in bisilicates and often holding a little quartz and some untwinned felspar, borders the area and may be a contact product of some kind. The boundary of the typical anorthosite against this rock is usually pretty sharp, but the latter passes gradually into the gneiss of the district. This intervening rock, however, has in the main the composition of gabbro, so that it becomes difficult to decide whether it represents a peculiar and abnormal, possibly altered, form of the gneiss or a contact phase of the anorthosite.

Black gabbro.

Close to the edge of the easterly development of the Morin anorthosite at New Glasgow, and running north for about six miles in a direction very nearly parallel to that of the limestone band in the gneiss just west of the contact, is a band of a peculiar gabbro nearly black in colour, which protrudes through the drift in a series of great roche moutonnée bosses, contrasting in a marked manner with the white anorthosite through which it cuts. The band is narrow, and immediately to the north of New Glasgow sends out an arm about a quarter of a mile long from its eastern side, which cuts across the foliation of the anorthosite. Under the microscope, the rock presents an extremely well marked cataclastic structure, the constituent minerals having been completely granulated under the great pressure to which they have been subjected.

Lakefield anorthosite.

Of the two smaller areas, that which lies to the west of St. Columbin, extending over into the Gore of Chatham and known as the Lakefield area, most closely resembles the Morin anorthosite just described. It is four and a half miles long and about a mile wide, only about one half of it, however, being embraced in the accompanying sheet. The outer portions are fine-grained, foliated, very poor in bisilicates and weather white. The inner portion of the area is more massive, and appears on the whole to be rather richer in ferro-magnesian constituents, which vary in amount from place to place, often giving the rock an irregular banded structure. A rapid change in strike is observable in this area, the anorthosite and its surrounding gneisses in the southern part striking on an average N. 30° W., while about the northern extremity both rocks strike N. 35° to 65° E. Less than a mile to the south of the area, at the very edge of the Laurentian escarpment, a diabase dyke cuts through the gneiss, which is here the country-rock. The dyke contains angular fragments of white anorthosite which in many places are so abundant as to make up the greater part of the whole. These fragments, which were brought up

by the molten diabase, probably mark an underground extension of this Lakefield area to the south.

Only a portion of the St. Jérome area, situated as it is immediately at the edge of the Laurentian axis, is exposed to view. The southern part of it is covered up and concealed by the flat-lying Palæozoic beds which come in a short distance to the south of the town. What proportion of the whole mass is represented by the portion exposed to view it is impossible to say. St. Jérome anorthosite.

It differs considerably from the other areas, in that the anorthosite composing it is not so typical in character, as well as in the fact that there intervenes between it and the gneiss a broad zone of rocks of intermediate character. The anorthosite, or gabbro as it should in this case more properly be called, is seen in its typical development on either side of the Canadian Pacific railway track a few hundred yards south of the station at St. Jérome. The large exposures here are situated about the middle of the area, toward its southern limit as exposed. At this point the rock is fine-grained, weathers brownish-gray and usually has a foliated structure. In some places the structure is more or less distinctly banded, owing to the alternations of portions rather rich in bisilicates with others consisting almost entirely of plagioclase. Individuals of dark-coloured plagioclase, usually small in size but sometimes as much as six inches in length, are abundant in places. They are frequently seen to be curved or twisted and are usually without good crystalline outlines.

Under the microscope, this rock is seen to be composed essentially of plagioclase and pyroxene, the former largely preponderating, with hornblende, biotite, garnet, iron-ore, and pyrite, as accessory constituents, and a few grains of quartz, calcite, chlorite, and apatite. The pyroxene is light-green in colour and is for the most part augite, which is often decomposed to calcite and chlorite—some of it however is trichroic in red, yellow and green tints and is probably hypersthene. The hornblende, which is green in colour, and the biotite are present in but very small amount. The garnet, which is pink in colour, and perfectly isotropic, is often well crystallized and usually has some approximation to good crystalline form. It is generally associated with iron-ore but often occurs in little strings through the rock. The iron-ore is titaniferous, as shown by the leucoxene which frequently appears as its decomposition-product. The quartz, which is present in very small amount associated with the bisilicates, may also be secondary. The little strings, an inch or even less in thickness, consisting of orthoclase and quartz, which run through the rock sometimes parallel Microscopical character.

to the stratification and sometimes across it, are rather abundant but are evidently of later origin.

The rock in its present form probably represents an advanced stage of granulation, for although but little is seen in the way of twisted grains and strain shadows, these are usually not well seen when the granulation is complete. The large remnants of plagioclase crystals on the other hand, which occur abundantly in many parts of the rock, indicate an extensive granulation. At the bridge over the North River at St. Jérome, on the western edge of the area, as well as at a point about a mile and a quarter further north near the northern end of the area, the same rock is well exposed, at the latter locality showing an exceeding well-marked cataclastic structure.

Zone of intermediate character.

This gabbro mass is surrounded by a zone of rocks of varied character, many of which strongly resemble the anorthosite in appearance, but which are quite different in composition. They are well exposed to the west of St. Jérome back from the North River. This zone includes a large quantity of ordinary orthoclase gneiss, and in it occurs the crystalline limestone already described as occurring to the south-west of the village, but it consists chiefly of rocks, which, in addition to augite and plagioclase, contain variable amounts of hornblende, orthoclase and quartz, and which are thus intermediate in character between the gneiss and the anorthosite, some of the many varieties represented approaching more nearly to gneiss and others more nearly to anorthosite in character and composition. It is thus a matter of great difficulty to trace upon a map the exact limits of this zone. In the accompanying sheet, this has been done as accurately as possible by the aid of a microscopical examination of the rocks from a number of points.

This zone surrounding the typical gabbro or anorthosite, probably represents a peculiar border facies of the latter, which in many places has intruded itself into the gneiss parallel to its foliation, giving an appearance of interstratification, while movements, induced by pressure subsequent to the intrusion, serve to render this appearance more deceptive. The orthoclase gneiss and the limestone in this zone are thus of the nature of inclosed or partially inclosed portions of the country-rock.

THE STRUCTURE OF THE AREA.

The foliation or banding of the gneiss in the western part of the Laurentian corner of the sheet has a general north-east strike, which to the east swings around and runs about due north. The change is well shown between St. Jérome and New Glasgow. The northerl

strike is well seen in the narrow mass of gneiss separating the two larger masses of anorthosite, as well as in the Laurentian to the east of the most easterly of these two masses. The anorthosite intrusions also, as has been mentioned, especially toward their sides, show a more or less well-marked foliation which coincides in direction with that of the adjacent gneiss. Thus, in the case of the most westerly of the two large anorthosite masses, which in its extension cuts across the strike of the gneiss, the foliation runs across the contact from the gneiss into the anorthosite ; while in the most easterly, which has been intruded into the gneiss in a north-and-south direction, the foliation of the two rocks coincides approximately with the direction of their lines of contact.

Relations of foliation to anorthosite boundary.

The strike in the immediate vicinity of the Lakefield anorthosite, as has been stated in speaking of that area, varies considerably.

North of the limits of the sheet, the strike of the foliation of the gneiss has been found to follow the windings of the boundary of the Morin anorthosite in a remarkable manner, making it evident that although the anorthosite breaks through the gneiss and cuts off the limestone bands in the latter, the foliation of the gneiss is not altogether an original structure, but is, in part at least, secondary, having been caused by the great pressure to which both rocks were subjected after the intrusion of the anorthosite, which has led to movements in the solid rocks.

ECONOMIC RESOURCES.

No mineral deposits of great value have as yet been found within this Laurentian area. The following, however, are worthy of note :—

Iron ore, St. Jérome.

Iron ore—Near St. Jérome, County of Terrebonne.—Two and a half miles south-west of St. Jérome, on the road which follows the northern bank of the river, there is a deposit of magnetic iron-ore. This occurs as several thin bands interstratified with a dark hornblendic rock and with the red orthoclase gneiss of this part of the area—the whole dipping toward the river at a very high angle. As seen in 1886, the ore was exposed by the removal of the drift deposits at a number of points along its strike, and a shallow opening had been made in it at one place. Subsequently, from October, 1891, until March, 1892, the deposit was worked by the Canada Iron Furnace Company ; during which time about 365 tons of ore was taken out and shipped to the company's furnaces at Radnor and there smelted. The following information has been kindly supplied to me by Mr. Arthur Cole, B. A. Sc., who was engaged in carrying out the work :—

"Most of the ore was taken out of a pit which when abandoned was about thirty-five feet deep, ten feet broad and twelve feet long. The ore-bed varied from two and a half feet to three feet in width, and was for the most part free from gangue. At a depth of thirty-five feet, the bed had narrowed down to a few inches and was then entirely lost. A drift was driven from the west end of the pit along the bed for about forty feet. The floor of the drift was about fifteen feet from the surface. Work was then discontinued, but was resumed in August, 1892, but this time at a point about one hundred yards further west along the outcrop of the bed. The ore here was in beds varying from a foot to a foot and a half in width. These beds often widened, but they would separate into two beds with an intervening bed of rock. In some places the limits of the beds were very clearly defined, but elsewhere the ore-body gradually faded away into the surrounding rock. About fifty tons were taken out of this opening, which was about ten feet deep and thirty feet long. Work was finally discontinued early in September, as it was found that too much rock was being handled."

A sample of the ore was analysed by me and found to have the following composition:—

Analysis.

Ferric oxide	59·059	p. c.
Ferrous oxide	26·807	"
Titanic acid	None.	
Phosphoric acid	·015	"
Sulphur	·001	"
Insoluble matter	9·897	"
Metallic iron	62·191	"
Phosphorus	·007	"
Sulphur	·001	"

The analysis brings out in an emphatic manner the distinction between the iron-ores of the orthoclase gneiss and those occurring in the anorthosite, the former being usually free from titanium, while the latter are rich in this deleterious constituent. This ore, although occurring so near the anorthosite, is quite free from titanium, while the iron-ores of the adjacent anorthosite areas always contain a large percentage of this element. To these belong the two following deposits.

Iron ore, Ste. Julienne.

Rawdon, Range II., Lot 2.—This deposit is situated near the village of Ste. Julienne, and although it has never been actually worked it has attracted a good deal of attention. It occurs in the Morin anorthosite near the eastern edge of the most easterly of the two larger developments of anorthosite shown in the accompanying sheet. The ore occurs in a foliated white-weathering variety of the anorthosite, rather rich in bisilicates and striking from N. 8° W. to N. 25° W. (magnetic) with a

nearly vertical dip. Several black diabase dykes occur in the vicinity. The ore varies a good deal in character, being much poorer in some places than in others, and often takes the form of bands from a few inches to several feet in width generally conformable, or nearly so, to the foliation of the anorthosite, but in a few cases cutting across it. Both the anorthosite and iron-ore are much twisted and faulted, and it is often difficult to determine whether the ore has been erupted through the anorthosite or whether the cases where it cuts across the anorthosite are to be attributed to faulting. It has, however, a general trend in the direction of the strike of the anorthosite, the principal mass being exposed for about 200 feet at right angles to this direction. The "ore" appears to be in reality a variety of the anorthosite, and in most places is too poor in iron to constitute an ore in the proper sense of the term. It is also highly titaniferous and contains iron-pyrites as a frequent constituent. Dr. Hoffmann found a specimen collected by me to contain :—

Highly titaniferous.

Metallic iron	42·29 p.c.
Titanic acid	Large amount.

Two samples examined by Dr. B. J. Harrington,* gave the following results :—

	I.	II.
Metallic iron	38·27 p.c.	40·71 p.c.
Titanic acid	33·67 "	33·64 "

while a third specimen, in which the iron was not determined, was found to contain :—

Titanic acid	35·09 p.c.

Wexford, Range I, Lot 7.—On this lot a small opening has been made in a dark-coloured heavy massive rock containing a certain amount of iron-ore. The field relations indicate that this is merely a local variety of the Morin anorthosite, exceptionally rich in the darker-coloured constituents of the rock, and a microscopic examination proves this to be the case. When thin sections are examined, the rock is seen to be composed essentially of a dark-coloured pyroxene with plagioclase and iron-ore. A not inconsiderable amount of apatite with a few grains of pyrite, garnet and biotite are also present. The proportion of iron-ore present is comparatively small. A specimen collected to represent the richest portion of the mass was examined by Dr. Hoffmann, with the following results :—

Iron ore, Wexford.

Metallic iron	20·27 per cent.
Insoluble residue	58·58 " "
Titanic acid	Decided reaction.

*Report of Progress, Geol. Surv. Can., 1876-77, p. 475.

Kilkenny, Range VII., Lot 7.—This deposit is an impure ochre or limonite, occurring near the edge of the Morin anorthosite, and apparently derived from the alteration of iron-pyrites which occurs as an impregnation in a band of anorthosite intercalated in the gneiss near the limits of the main area. The band of rock through which this limonite is distributed has a considerable width, but could not be everywhere examined at the time of my visit owing to a bush fire which was raging. No mass of the iron-ore over one foot in thickness could be found, however, and the deposit is, I should judge, valueless as a source of iron.

A specimen of the limonite was examined by Dr. Hoffmann, and was found to contain :—

Metallic iron	25·75 per cent.
Insoluble matter	Large amount.

It also contained a considerable quantity of manganese, but no titanium.

Anorthosite.

Anorthosite.—This rock, although it has been but little used for building purposes, might in many cases be employed with advantage for decorative construction. It may be obtained in unlimited amount in the Morin area, of any colour from deep violet to white. The opalescent varieties occur but sparingly in this district. To judge of its appearance when cut and polished, two large blocks, one of the violet and one of the white variety were collected and six-inch cubes were prepared from them. These were exhibited in the Colonial and Indian Exhibition held in London in 1886. The violet variety was collected on the eastern side of range II. of the township of Morin, and when polished presented a handsome appearance, but was rather dark in colour. The white variety, which was taken from the large exposures at New Glasgow, took a high polish and in this state was found to bear a striking resemblance to marble. It is more difficult to work than marble, but would be more durable and would retain its polish better, especially in exposed situations, and might well be employed for many purposes in construction.

On account of its toughness and durability, this white anorthosite from New Glasgow has been extensively used for paving stones in the city of Montreal, especially on streets where there is a heavy freight traffic. A number of small quarries have been opened in the vicinity of New Glasgow, while a larger one is operated about two miles to the north of the village. The stone is blasted out in large blocks and is then dressed to the required size by means of large hammers. The industry which has thus sprung up is quite extensive, up to the time of my last visit in August, 1891, 541,000 anorthosite paving blocks having been shippped to Montreal by rail.

APPENDIX

Preliminary Lists of the Organic Remains occurring in the various Geological Formations comprised in the South-west Quarter-sheet Map of the Eastern Townships of the Province of Quebec.

BY

HENRY M. AMI, M.A., D.Sc., F.G.S.

The following formations are included in this Appendix, in ascending order :—

Potsdam sandstone.
Calciferous formation.
Chazy formation.
Phillipsburg series (= Fort Cassin rocks).
Quebec City formation.
Trenton, including Black River.
Utica.
Lorraine.
Silurian, including Lower Helderberg and possibly older.
Devonian, including Cauda-galli Grit and Corniferous ?

The fossil remains enumerated in this Appendix are grouped by localities under each formation, and under each locality, they are arranged in zoological order.

POTSDAM SANDSTONE.

I. Beauharnois, Que., County of Beauharnois (Geological Survey collection) :—

1. Protichnites septemnotatus, Owen.
2. " octonotatus, Owen.
3. " latus, Owen.
4. " multinotatus, Owen.
5. " lineatus, Owen.
6. " alternans, Owen.

II. Ste. Anne, Jacques Cartier County, Que. ; (Geological Survey collection) :—

1. Scolithus Canadensis, Billings.

CALCIFEROUS FORMATION.

III. Ste. Anne, Jacques Cartier County, Que.; collectors, Logan, Richardson, M. Ramsay, Murray and Ami (Geological Survey collection):—

Hydroida:

1. Stromatocerium calciferum, Dawson.

Brachiopoda:

2. Lingula Irene, Billings.

Gastercpoda:

3. Pleurotomaria gregaria, Billings.
4. Murchisonia Anna, Billings.

Cephalopoda:

5. Orthoceras ordinatum, Billings.

Ostracoda:

6. Leperditia Anna, Jones.

IV. Ste. Anne, Jacques Cartier County, Que. (Dawson collection; Peter Redpath Museum of McGill University, Montreal):—

Brachiopoda:

1. Orthisina grandœva, Billings.

Gasteropoda:

2. Pleurotomaria Anna, Billings.
3. " Laurentina, Billings.
4. Murchisonia Anna, Billings.

Cephalopoda:

5. Orthoceras. (Several species.)

V. Beauharnois, Que., Chateauguay County, and Norton's Creek, Beauharnois County, Que.; collector, Richardson, 1851 and 1853 (Geological Survey collection):—

1. Palæophycus tubularis, Hall.
2. " Beauharnoisensis, Billings.
3. Camerella calcifera, Billings.
4. Ecculiomphalus Atlanticus, Billings.
5. Ophileta complanata, Vanuxem (=Ophileta compacta, Salter).
6. Pleurotomaria calcifera, Billings.
7. Bathyurus conicus, Billings.

VI. Beauharnois, Que., Beauharnois County (Peter Redpath Museum collection):—

1. Ophileta complanata, Vanuxem (=O. compacta, Salter).

VII. Ormstown, quarry one mile west of village, Chateauguay County; collector, Mr. T. N. Walsh (Peter Redpath Museum):—

Brachiopoda:

1. Orthis sp.

Gasteropoda:

2. Ophileta complanata, Vanuxem.
3. " disjuncta, Hall.
4. Pleurotomaria, sp.
5. Murchisonia, sp.

Cephalopoda:

6. Lituites, sp.
7. Endoceras Becki (?), Billings.

VIII. St. Eustache, Two Mountains County, Que.; collectors, Murray and Richardson (Geological Survey collection):—

Brachiopoda:

1. Lingula Mantelli, Billings.

Cephalopoda:

2. Orthoceras Montrealense, Billings.

IX. Phillipsburgh, Que.; R. W. Ells, 1890 (in buff-weathering dolomite):—

Echinodermata:

1. Palæocystites sp., allied to P. tenuiradiatus, Hall.

Brachiopoda:

2. Orthis Minna, Billings.

Gasteropoda:

3. Subulites, sp.
4. Ophileta complanata, Vanuxem.
5. (?) Raphistoma proavium, Whitfield.
6. Murchisonia Anna (?), Billings.
7. " gracilens (?), Whitfield.
8. " (?) confusa, Whitfield.

Trilobita:

9. Amphion Salteri, Billings.
10. Cheirurus, sp. indt.

CHAZY FORMATION.

X. St. Dominique, Quebec; R. W. Ells, 1890 (from a dark gray semi-crystalline limestone, weathering yellowish brown—at times arenaceous):—

Echinodermata :

1. Crinoidal or cystidean fragments.

Zoophyta :

2. (?) Columnaria incerta, Billings.

Bryozoa (?) :

3. Solenopora compacta, Billings.
4. Branching monticuliporoid, not determined.

Brachiopoda :

5. Orthis acuminata, Billings.
6. Orthis Porcia (?), Billings. (In the arenaceous strata.)

Gasteropoda :

7. Obscure specimen, not determined.

Trilobita :

8. Ampyx Halli, Billings.
9. Asaphus canalis, Conrad.
10. Asaphus, *cf.* A platycephalus, Stokes. (=Isotelus gigas, deKay.)

XI. St. Dominique, Quebec; W. E. Deeks, 1891 :—

Hydrozoa :

1. (?) Strephochetus, sp.

Echinodermata :

2. Palæocystites tenuiradiatus, Hall.*
3. Crinoidal or cystidean fragments.

Bryozoa :

4. Branching monticuliporoidea.

Brachiopoda :

5. (?) Orthis pigra, Billings.
6. Orthis platys, Billings.
7. " costalis, Hall.
8. " sp. indt.

Gasteropoda :

9. Pleurotomaria, *cf.* P. Laurentina, Billings.
10. " (Raphistoma) Crevieri, Billings.
11. Raphistoma planistria, Hall.
12. " lenticulare (?), Sowerby.
13. Trochonema umbilicatum, Hall.
14. Ophileta, *cf.* O. complanata, Vanuxem.
15. Bucania, sp.

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* Also Bolboporites Americanus, Billings.

Pteropoda :

16. (??) Hyolithes, sp.

Trilobita :

17. Ampyx Halli, Billings.
18. Remopleurides, n. sp.
19. Bathyurus, sp.
20. Bathyurus, *cf.* B. Angelini, Billings.
21. " extans, Hall or allied species.
22. Asaphus canalis, Conrad.
23. Illænus globosus (?), Billings.
24. Amphion or Cheirurus, sp.

XII. St. Dominique, Quebec. List of species recorded by Mr. Billings in "Geology of Canada," p. 206, 1863.

Bryozoa:

1. Ptilodictya fenestrata (MS ?).

Brachiopoda :

2. Strophomena alternata, Conrad.
3. Orthis platys, Billings.
4. " borealis, Billings.

Pelecypoda :

5. Vanuxemia Montrealensis, Billings.

Gasteropoda :

6. Pleurotomaria Crevieri, Billings.

Trilobita :

7. Ampyx Halli, Billings.

XIII. St. Dominique, Quebec; T. C. Weston, 1879, and James Richardson, date not given :—

Echinodermata ?

1. Bolboporites Americanus, Billings.

Brachiopoda :

2. Orthis platys, Billings.
3. " (Hebertella) borealis, Billings.

Gasteropoda :

4. Pleurotomaria (Raphistoma) Crevieri, Billings.

Trilobita :

5. Ampyx Halli, Billings.
6. Asaphus marginalis (?), Hall. (? = A. canalis, Conrad).

XIV. Two miles south of Abbotsford, Papineau Range Road, Abbotsford, Quebec; W. E. Deeks, 23rd June, 1891 :

Zoophyta :

1. Streptelasma (?), sp.

Echinodermata :

2. Blastoidocrinus carchariædens, Billings.
3. Bolboporites Americanus, Billings.
4. Crinoidal or cystidean fragments, not determined.

Bryozoa :

5. Stictopora glomerata, Hall. A form resembling that figured by Hall in vol. i., Pal. N.Y., 1847, from the Chazy limestone.

Brachiopoda:

6. Leptæna, fasciata, Hall. Probably a Rafinesquina.
7. Orthis (Hebertella) borealis, Billings.
8. " or Zygospira sp., too imperfect for determination.

Gasteropoda :

9. Metoptoma Montrealensis, Billings.
10. Raphistoma planistria, Hall.
11. Pleurotomaria calyx, Billings.
12. Maclurea, sp.

Trilobita :

13. Asaphus canalis, Conrad.
14. Harpes or Trinucleus sp., shewing sculptured outer margin of cephalic shield.

XV. Grande Ligne Quarries, Que. ; W. E. Deeks, 27th June, 1891.

Hydrozoa :

1. Stromatocerium or Cryptozoon, sp.

Echinodermata :

2. Blastoidocrinus carchariædens, Billings.
3. Palæocystites tenuiradiatus, Hall.
4. " sp.
5. Cystidean fragments, undetermined.

Bryozoa :

6. Stictopora, sp., *cf.* S. glomerata, Hall.
7. Amplexopora (?), sp., or other genus of branching monticuliporoid.
8. Dicranopora, sp.
9. Solenopora or Cryptozoon, sp.

Brachiopoda :

10. Leptæna, sp.
11. Orthis (Hebertella) borealis, Billings.
12. " platys (?), Billings.
13. " Porcia, Billings.
14. " probably O. (Dalmanella) perveta, Conrad.

15. Rhynchonella plena, Hall.
16. Atrypa (? Zygospira) acutirostra, Hall,
17. Triplesia, sp.

Gasteropoda :

18. Metoptoma, sp.
19. Pleurotomaria calyx, as of Billings.
20. Raphistoma planistria, Hall.

Pteropoda :

21. (?) Hyolithes, sp.

Cephalopoda :

22. Endoceras velox, (= Orthoceras velox, Billings.
23. Orthoceras bilineatum, Hall.

Trilobita :

24. Bathyurus spiniger, Billings.
25. Asaphus canalis, Conrad.
26. Illænus arcturus, Hall.
27. " globosus, Billings.
28. " Bayfieldi, Billings.

Ostracoda :

29. Leperditia Canadensis, v. nana, Jones.

XVI. Island of Montreal, Que.; Thos. Curry, 1888. (Specimens sent to the Geological Survey Dept. for identification—the property of the Peter Redpath Museum of McGill College, Montreal) :—

Echinodermata :

1. Malocystites Murchisoni, Billings.
2. " sp.
3. Palæocystites tenuiradiatus, Hall.

XVII. Bord à Plouffe, Que.; W. E. Deeks, 6th July, 1891.

Bryozoa :

1. Intricaria, sp.
2. Branching Monticuliporoids.

Brachiopoda :

3. Orthis (Hebertella) borealis, Billings.
4. " platys, Billings.
5. " Porcia, Billings.
6. " sp.
7. (?) Rafinesquina alternata, (= Strophomena alternata, Conrad *et auct.*
8. Orthis or Strophomena, sp. indt. Too imperfect for identification.

Trilobita :

9. Remopleurides sp.
10. Asaphus, sp., portion of cephalic shield.

Ostracoda :

11. Leperditia, sp., a rather large form for the Chazy formation.

XVIII. St. Martin Junction, Que.; W. E. Deeks, 7th March, 1891 :—

Echinodermata :

1. Blastoidocrinus carchariædens, Billings.
2. Malocystites Murchisoni, Billings.
3. Palæocystites tenuiradiatus, Hall.

Bryozoa :

4. Callopora or Calloporella sp. Bryozoary, consisting of two kinds of zoœcia, one, larger and regularly disposed in rows; the other, minute mesopores filling intervening spaces.
5. Dicranopora (?), sp.
6. Stictopora glomerata (?), Hall.
7. Frondescent forms of monticuliporoidea.
8. Ramose or branching monticuliporoidea.

Brachiopoda :

9. Lingula, sp. *cf.* L. Huronensis, Billings.
10. Orthis (Hebertella) borealis, Billings.
11. " platys, Billings.
12. " disparilis, Billings.
13. Rafinesquina fasciata or alternata. Same form occurs in the Chazy of L'Orignal, Ont.
14. Rhynchonella plena, Hall.

Gasteropoda :

15. Raphistoma planistria, Hall.

Trilobita :

16. Remopleurides (?) sp.
17. Bathyurus, sp., *cf.* B. Angelini, Billings.
18. Asaphus, sp., fragments of head shield and pleuræ of axis and thorax.
19. Illænus, *cf.* I. globosus, Billings.
20. " sp. indt.
21. Cheirurus, sp. indt.
22. Lichas (?) sp.
23. Harpes, sp.

XIX. Joliette, Que. The following species were collected by N. J. Giroux in 1891, close to the bridge over L'Assomption River, near the Canadian Pacific railway station.

Echinodermata :

1. Palæocystites tenuiradiatus, Hall.

Bryozoa :

2. Monticuliporoidea; requiring microscopic sections before identification.

Brachiopoda :

3. Lingula, sp. indt.
4. Orthis (Hebertella) borealis, Billings.

Gasteropoda :

5. Pleurotomaria Crevieri (?), Billings.
6. Raphistoma planistria, v. parvum, Hall.
7. (?) Bucania sulcatina, Emmons.

Cephalopoda :

8. Orthoceras (?), sp. indt.

XX. Joliette, Que. "Industry Village" of "Geology of Canada," 1863, p. 133.

Gasteropoda :

1. "Pleurotomaria staminea, Hall.
   (= Raphistoma stamineum, Hall.)

XXI. Island of Montreal, Hochelaga County, Que.; collectors, Logan, Billings, Richardson and Bell (Geological Survey collection):—

Hydroida :

1. Stromatocerium rugosum, Hall.

Cystoidea and Blastoides :—

2. Malocystites Murchisoni, Billings.
3. " Barrandei, Billings.
4. Blastoidocrinus carchariædens, Billings.
5. Palæocystites tenuiradiatus, Hall.
6. Glyptocystites Forbesi, Billings.
7. Bolboporites Americanus, Billings. This is probably a portion of the interior of one of the cystoidea so prevalent in these rocks.

Crinoidea :

8. Crinoidal columns.

Bryozoa :

9. Monotrypella undulata, Nicholson.
10. Stenopora patula, Billings.

Brachiopoda :

11. Lingula Belli, Billings.
12. Rafinesquina alternata, (Conrad).
13. Orthis (Dalmanella) perveta, Conrad.
14. " " subæquata, Conrad.
15. " " gibbosa, Billings.

16. Orthis Porcia, Billings.
17. " disparilis, Billings.
18. Rhynchonella plena, Hall.

Pelecypoda ;

19. Vanuxemia Montrealensis, Billings.

Gasteropoda :

20. Metoptoma Montrealensis, Billings.
21. Pleurotomaria immatura, Billings.
22. " calyx, Billings.

Vermes :

23. Serpulites splendens, Billings.

Trilobita :

24. Sphærexochus parvus, Billings.

XXII. Island of Montreal, Que.; outcrops of the Chazy formation. Peter Redpath Museum collection :—

Cystoidea :

1. Bolboporites Americanus, Billings.
2. Palæocystites, sp.
3. Palæocystites tenuiradiatus, Hall.
4. Malocystites Murchisoni, Billings.

Blastoidea :

5. Blastoidocrinus carchariædens, Billings.

Crinoidea :

6. Rhodocrinus asperatus, Billings.

Bryozoa :

7. Phylloporina aspera, Hall.
8. Monticulipora (?), sp.

Brachiopoda :

9. Orthis platys, Billings.
10. " (Hebertella) imperator, Billings.
11. " (Dalmanella) perveta, Conrad.
12. Rhynchonella plena, Hall.

Gasteropoda :

13. Pleurotomaria, sp.

Trilobita :

14. Sphærexochus parvus, Billings.

XXIII. Caughnawaga, Laprairie County, Que.; Peter Redpath Museum collection :—

Echinodermata :

1. Crinoidal or cystidean fragments.
2. Blastoidocrinus carchariædens, Billings.
3. Bolboporites Americanus, Billings.

Gasteropoda :

4. Raphistoma stamineum, Hall.

XXIV. Caughnawaga, Laprairie County, Que.; collectors, Logan, Billings and Richardson (Geological Survey collection):—

Cystoidea :

1. Glyptocystites Forbesi, Billings.

Brachiopoda :

2. Orthis acuminata, Billings.

PHILLIPSBURG SERIES.

XXV. Road between Phillipsburg and St. Armand, County of Missisquoi, Que.; collected by R. W. Ells, J. F. Whiteaves and W. E. Deeks, 1890:—

Echinodermata :

1. Crinoidal or cystidean fragments.

Brachiopoda :

2. Lingula, sp. indt.
3. Orbiculoidea, sp. nov. (?)
4. Orthis (?) Armanda, Billings.
5. Orthis Electra, Billings.
6. " Minna, Billings.
7. Hemipronites (?), sp. indt.
8. Triplesia lateralis, Whitfield.
9. " calcifera (?), Billings.

Gasteropoda :

10. Pleurotomaria Missisquoi, Billings.
11. " sp. nov. (?), non. P. Hortensia, Bill., nor P. Hortensia, Billings, as of Whitfield, but closely related.
12. " difficilis, Whitfield.
13. " Beekmanensis, Whitfield.
14. " sp. with alation along the outer edge of the body volution.
15. " sp. allied to P. Missisquoi, Billings.
16. Murchisonia, sp., *cf.* M. Vesta, Billings.
17. " Missisquoi, Billings.
18. Bellerophon Palinurus, Billings.
19. Lophospira Cassina, Whitfield.
20. " (?) sp. indt.
21. Holopea Cassina, Whitfield.
22. " arenaria (?), Billings.

23. Holopea, sp. indt.
24. Euomphalus circumliratus, Whitfield.
25. " sp., *cf.* E. calciferus, Whitfield.
26. Ophileta complanata, Vanuxem.
27. Ecculiomphalus volutatus, Whitfield.
28. Raphistoma stamineum, Hall (?=Pleurotomaria docens or calyx, Bill.
29. " sp. indt., No. 1.
30. " sp. indt., No. 2.
31. Maclurea ponderosa, Billings.
32. " sp.
33. Subulites obesus, Whitfield.
34. (?) Calaurops lituiformis, Whitfield.

Cephalopoda:

35. Endoceras, sp. nov. (?)
36. Orthoceras Missisquoi, Billings.
37. " Brainerdi, Whitfield.
38. " explorator, Billings.
39. " Cataline (?), Billings.
40. " Lamarcki, Billings.
41. " bilineatum, Hall (as of Whitfield).
42. Litoceras, sp., *cf.* L. Whiteavesi, Hyatt, (=Nautilus versutus, pars. Billings.
43. " sp.
44. Nautilus (?) sp. A large form. Exact generic relation not definitely ascertained.
45. Schroederoceras Eatoni, Whitfield.
46. " " var. Cassinensis, Whitfield.
47. Eurystomites Kelloggi, Whitfield.
48. " sp. indt.

Trilobita:

49. Agnostus Galba, Billings or a nearly related species.
50. Remopleurides affinis, Billings.
51. Bathyurus Saffordi, Billings (abundant).
52. " sp., probably a new species, closely related to B. marginatus, Billings.
53. " conicus, Billings. (Not the Bathyurus conicus of Whitfield.)
54. " sp., *cf.* B. Cordai, Billings.
55. " sp., with a long and fairly stout terminal spine at the extremity of the caudal shield; a much larger species than B. caudatus.
56. Bathyurellus expansus, Billings.
57. " glandicephalus, Whitfield.

58. Asaphus canalis, Conrad.
59. Illænus simulator, Billings.
60. " sp. Too imperfect for identification.
61. Cheirurus, sp.
62. Lichas, sp., *cf.* L. Champlainenense, Whitfield.

Ostracoda :

63. Leperditia, sp. indt.

XXVI. Boundary line, lot 122, east of St. Armand P. O., 150 yards west of road to mill, Missisquoi Co., Que. Collectors : R. W. Ells and W. E. Deeks, 1891.

1. (?) Solenopora compacta, or Girvanella, sp.

Echinodermata :

2. Crinoidal fragments.

Brachiopoda :

3. Orthis, sp. indt.
4. " sp. with acutely rostrate umbo.
5. " sp. No. 3, not determinable.
6. Strophomenoid shell, with thread-like striæ at the beak which widen out anteriorly into coarse angular costæ.
7. Triplesia, sp.

Gasteropoda :

8. Pleurotomaria, sp. indt.
9. Ophileta, sp., *cf.* O. complanata, Vanuxem.
10. " sp.
11. Raphistoma or Trochonema, sp.

Cephalopoda :

12. Orthoceras Missisquoi vel O. furtivum, Billings.

Trilobita :

13. Dolichometopus (?) sp.
14. Bathyurus, sp., probably a new species.
15. " Saffordi, Billings.
16. Asaphus canalis, Conrad, or a very closely related species.
17. Cheirurus or Amphion, sp.

Ostracoda :

18. Leperditia, sp.

XXVII. Bedford, Que., lot 20, range VI., tp. of Stanbridge, Que. J. F. Whiteaves, 1878.

Brachiopoda :

1. Lingula, sp., probably a new species.
2. Orbiculoidea, n. sp.
3. Orthis Minna, Billings.

Gasteropoda :

4. Bellerophon Palinurus, Billings.
5. Maclurea ponderosa, Billings.

Trilobita :

6. Agnostus Galba (?), Billings.
7. Remopleurides affinis, Billings.
8. Bathyurus Saffordi, Billings.
9. " breviceps (?), Billings.
10. Bathyurellus expansus, Billings.
11. Illænus simulator, Billings.

Ostracoda :

12. Leperditia, n. sp.

NOTE.—There are also fragments of what appear to be a Cheirurus or Amphion and a cast of the larger or body volution of a large gasteropod probably a Holopea or Pleurotomaria.

XXVIII. Phillipsburg, Que.; Billings, &c. (Geological Survey collections.)

The following species were described by Mr. Billings from the Phillipsburg limestones as follows :—

Echinodermata :

1. Palæocystites tenuiradiatus, Hall. Pal. Foss., vol. I., p. 63.

Brachiopoda :

2. Orthis (?) Armanda, Billings, ibid., p. 303.

Gasteropoda :

3. Pleurotomaria Postumia, Billings, ibid., p. 91.
4. Murchisonia Hyale, Billings, ibid., p. 33.
5. Pleurotomaria Missisquoi, Billings, ibid., p. 191.
6. Ophileta abdita, Billings, ibid., p. 189.
7. Maclurea ponderosa, Billings, ibid., p. 239.
8. Metoptoma Niobe, Billings, ibid., p. 37.

Cephalopoda :

9. Nautilus Pomponius, Billings, ibid., p. 26.
10. Cyrtoceras Aristides, Billings, ibid., p. 316.
11. Orthoceras repens, Billings, ibid., p. 312.
12. " Catulus, Billings, p. 313.
13. " Missisquoi, Billings, p. 314.
14. " Cato, Billings, p. 315.
15. " Cataline, Billings, p. 315.
16. " Sayi, Billings, p. 315.
17. " Tityrus, Billings, p. 316.

Trilobita :

18. Dikelocephalus Missisquoi, Billings, p. 199.

Besides the above Phillipsburg fossils recorded by Billings, Prof. Whitfield also records the occurrence of Cryptozoon Steeli, Brainerd and Seely, in Bull. Am. Mus. N. Hist., vol. III., No. 1, p. 6, 1890.

XXIX. One mile and a half east of Phillipsburg, Que.; purchased from George Hogle, Esq., 1890.

Brachiopoda :

1. Orthis, sp. indt.

Gasteropoda :

2. Pleurotomaria, sp.

Cephalopoda :

3. Orthoceras, *cf.* O. furtivum, Billings.
4. " sp.
5. " sp., *cf.* O. Tityrus, Billings.

Trilobita :

6. Bathyurus, sp., *cf.* B. Saffordi, Billings.

XXX. Lot 22, Con. VI., Stanbridge, Que.; R. W. Ells, 1890.

Echinodermata :

1. Crinoidal fragments.

Brachiopoda ;

2. Lingulella, sp. nov.
3. Discina, sp. nov.
4. Orthis Corinna, Billings.
5. " Armanda, Billings.
6. " cf. O. Minna, Billings.
7. " sp. nov.
8. " sp. indt.
9. Leptella decipiens (?), Billings.
10. " sp.
11. Strophomena Aurora (?), Billings.
12. " sp. nov. With prominent thread-like radiating lines, between which can be seen numerous and concentrically arranged wrinkles or rugæ resembling those of *Strophomena (Leptagonia) rhomboidalis*, Wilckens, and *Strophomena Stephani*, Barrande.

13. Porambonites, sp. nov., or other rhynchonelloid brachiopod, whose affinities are not as yet ascertained.

Gasteropoda :

14. Pleurotomaria, sp.
15. Clisospira curiosa, Billings.

Cephalopoda :

16. Orthoceras Missisquoi, Billings.
17. " sp.

Cirripedia :

18. Turrilepas, sp. nov. No. 1. Opercular valve of a species of Turrilepas with coarsely-marked raised or prominent concentric lines of sculpture when seen under a magnifying lens.

19. Turrilepas, sp. nov. No. 2. Opercular valve marked by very fine, closely-arranged, concentric lines. Both species (18) and (19), Nos. 1 and 2 of this collection—are distinct from Turrilepas Canadensis, Woodward, described by Dr. Henry Woodward* from the Utica of Ottawa, Canada.

Trilobita :

20. Agnostus, sp. nov.
21. " Galba, Billings, or n. sp.
22. (?) Dikelocephalus, sp. (pygidia).
23. (?) Dolichometopus, sp.
24. Remopleurides affinis, Billings.
25. Bathyurus Saffordi, Billings.
26. " Nero (?), Billings, or a very closely related form.
27. " sp.
28. Bathyurellus expansus, Billings.
29. " validus (?), Billings.
30. Asaphus Huttoni (?), Billings.
31. " canalis (?), Conrad
32. Illænus consimilis, Billings.
33. " arcuatus, Billings.
34. " incertus, Billings.
35. " simulator, Billings.
36. " tumidifrons (?), Billings.
37. Cheirurus prolificus, Billings.
38. " Vulcanus (?), Billings.
39. " sp.
40. Lichas Jukesii, Billings.
41. Harpides desertus, Billings.
42. Harpes Granti, Billings.

XXXI. Lot 22, Con. VI., Stanbridge, Que. Collection made by R. W. Ells, J. F. Whiteaves, and W. E. Deeks, in 1891.

The following additional species to list from preceding locality were noted :—

Bryozoa :

1. Zoarium somewhat resembling that of *Intricaria.*

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*Geol. Mag., vol. VI., p. 271, London, 1889.

Gasteropoda (?) :

2. Clisospira curiosa, Billings.

XXXII. One mile south of Bedford, Que., R. W. Ells, 1890.

Gasteropoda :

1. Maclurea ponderosa, Billings.

XXXIII. Stanbridge, Que., J. F. Whiteaves, 1890.

Gasteropoda :

1. Pleurotomaria, sp.
2. Maclurea ponderosa, Billings.

Trilobita :

3. Bolbocephalus (?), sp. indt.

XXXIV. Three-eighths of a mile north of Mystic Station, C.P.R., Stanbridge, Que., R. W. Ells and W. E. Deeks, 1890.

Brachiopoda :

1. Leptæna (Plectambonites), sp.
2. Orthis (?), Armanda, Billings.
3. Orthis Minna, Billings.
4. " sp. indt., No. 1.
5. " " No. 2.

Gasteropoda :

6. Maclurea ponderosa, Billings.

Cephalopoda :

7. Orthoceras sp. Annulations distinct, showing transverse lines of growth developed and preserved on the test of the shell.

Trilobita :

8. (?) Remopleurides, sp.
9. Asaphus, sp., *cf.* A. canalis, Conrad.
10. Illænus, sp., *cf.* I. fraternus, Billings.
11. " tumidifrons, Billings.
12. " sp. indt.
13. Cheirurus Polydorus ? Billings.
14. " (?) sp. indt.

XXXV. Between Bedford and Farnham, Que. (Mystic station), Dr. R. W. Ells, 1890.

Brachiopoda :

1. Trematis or Lingula, sp. indt.
2. (?) Acrotreta, sp. indt.
3. Eichwaldia, sp.
4. Skenidium (?) sp.

5. Orthis apicalis, Billings.
6. Triplesia radiata, Whitfield.

Pteropoda :

7. Conularia plana, Whitfield. Or a closely related species.

Cephalopoda :

8. Cyrtoceras, sp.
9. Orthoceras, sp.

Trilobita :

10. Bathyurus, sp.
11. " Cordai, Billings.
12. " Saffordi, Billings.
13. Æglina, sp.
14. Amphion Westoni, Billings.
15. " or Cheirurus, sp.
16. Proëtus micropyge ? Corda. Or a closely related and new species.

Ostracoda :

17. Primitia cristata ? Whitfield.

XXXVI. One mile and a quarter east of Phillipsburg, north of the road to St. Armand, Que. Dr. Ells, Mr. J. F. Whiteaves, and Mr. W. E. Deeks, August 11th, 12th, 13th and 14th, 1890.

Hydrozoa :

1. Stromatocerium or Cryptozoon, sp.

Brachiopoda :

2. Leptæna ? sp. indt.
3. Orthis, sp., *cf.* O. Minna, Billings.
4. " Corinna, Billings.
5. " Armanda, Billings.
6. " Electra, Billings. (= Dalmanella Electra.)
7. " n. sp.
8. (?) sp. indt.
9. Triplesia calcifera, Billings.
10. " radiata, Whitfield.
11. " sp.

Gasteropoda :

12. Pleurotomaria Missisquoi, Billings.
13. " vagrans ? Billings.
14. " *cf.* P. difficilis, Whitfield.
15. " Beekmanensis, Whitfield. (? = P. Calcifera, Billings.)
16. Murchisonia, sp. No. 1.
17. " sp. No. 2.

18. Helicotoma, sp.
19. Bellerophon, sp.
20. Tryblidium pileolum, Whitfield.
21. Platyceras acutum, Whitfield.
    (= Tryblidium acutum, Whitfield.)
22. Ecculiomphalus (Phanerotinus) intortus, Billings.
23. " sp. indt.
24. Ophileta bella, Billings. (Euomphalus proper).
25. Calaurops lituiformis, Whitfield.
26. Fusispira, sp. indt.

Cephalopoda:

27. Orthoceras, sp., *cf.* O. bilineatum, Hall, also O. Cataline, Bill., Fig. 5, Bull. Am. Mus., N.H., vol. III., pl. 2.
28. Orthoceras, n. sp.
29. " sp.
30. " Lamarcki, Billings, or a closely related species.
31. " Cataline, Billings.
32. " furtivum (?), Billings.
33. Cyrtoceras, sp., *cf.* C. Raei, Whitfield.
34. " Kirbyi (?), Whitfield.
35. " (?), sp.
36. Gyroceras, sp., No. 1.
37. " (?) sp., No. 2.
38. Lituites Farnsworthi, Billings.

Trilobita:

39. Asaphus canalis, Conrad.
40. " sp.
41. Nileus, sp. indt.
42. Bathyurus Saffordi, Billings.
43. Bathyurellus expansus (?) Billings.
44. Bolbocephalus Seelyi, Whitfield.
45. Illænus, sp.
46. Cheirurus, sp.

XXXVII. Lot 21, range VI., Stanbridge, Quebec; Ells and Deeks, 1890.

Hydrozoa:

1. Hyalostelia (?) sp. Rod-like spicule (?) of a palæozoic sponge related to this genus, if not the same.
2. Cryptozoon, sp., *cf.* C. Steeli, Brainerd and Seely (n. sp.)—Bull. Am. Mus. Nat. Hist., vol. II.

Brachiopoda :

3. Leptæna (Plectambonites) sp.; a large form.
4. Orthis Evadne (?), Billings.
5. " sp. indt.
6. " sp. No. 1.
7. " sp. No. 2.
8. Triplesia radiata, Whitfield.
9. " calcifera, Billings.
10. " *cf.* T. lateralis, Whitfield.

Gasteropoda :

11. Pleurotomaria (?) sp., not sufficiently well preserved to ascertain definitely.

Trilobita :

12. Bathyurus Saffordi, Billings.
13. " sp., *cf.* B. quadratus, Billings.
14. " sp.
15. Illænus, sp.

XXXVIII. Stanbridge, Que., probably lot 20, range VI.; described and recorded by E. Billings in "Palæozoic Fossils," vol. i, pp. 301–335.

Brachiopoda :

1. Orthis Corinna, p. 302.
2. " Minna, p. 303.
3. Camerella breviplicata, p. 304.
4. " polita, p. 305.
5. " (?) costata, p. 305.

Gasteropoda :

6. Murchisonia Missisquoi, p. 307.
7. Bellerophon Palinurus, p. 311.
8. Ophileta bella, p. 310.

Trilobita :

9. Asaphus (?) curiosus, p. 318.
10. Bathyurellus expansus, p. 318.
11. Amphion Westoni, p. 321.
12. " convexus, p. 323.
13. Cheirurus Glaucus, p. 323.
14. " Vulcanus, p. 324.
15. " prolificus, p. 325.
16. Remopleurides affinis, p. 325.
17. Illænus simulator, p. 327.
18. Harpes Granti, p. 326.

19. Illænus incertus, p. 332.
20. Lichas Jukesii, p. 335.

QUEBEC (CITY) FORMATION.

XXXIX. Lot 19, range II., Stanstead, Que. Collected by H. M. Ami and R. W. Ells, 1886, in a cutting on the main road, on the eastern side of Lake Memphremagog, about 100 yards north of the entrance to the grounds and residence of the late Sir Hugh Allan. Determined by Dr. Charles Lapworth.

Graptolitoidea :

1. Diplograptus foliaceus, Murchison (=Diplograptus pristis, Hall.)
2. Dicellograptus, sp., allied to D. Forchammeri, Geinitz.
3. " divaricatus, Hall.
4. Climacograptus perexcavatus, Lapworth.
5. Corynoides calycularis, Nicholson.
6. Dicranograptus sp. (?).

XL. Lot 7, range XV., Magog, Que. Collected by H. M. Ami and R. W. Ells, 1886, about 150 yards south of the forks of the road along the west side of Lake Memphremagog. Determined by Dr. Charles Lapworth.

Graptolitoidea :

1. Dicranograptus ramosus, Hall.
2. Diplograptus angustifolius, Hall.
3. " foliaceus, Murchison.
4. " perexcavatus, Lapworth.
5. Climacograptus bicornis, Hall.
6 " cœlatus, Lapworth.

XLI. Castle Brook, Willard's Mill, lot 5, range XV., township of Magog, Que. Collections made here by Dr. R. W. Ells and W. E Deeks, 1890, and by H. M. Ami assisted by H. B. Cushing, 1894.

1. Leptograptus, sp. indt.
2. Dicellograptus, probably n. sp.
3. Dicranograptus ramosus, Hall.
4. Climacograptus bicornis, Hall.
5. " " var. scalaris.
6. " n. sp.
7. Diplograptus foliaceus, Murchison.
8. " angustifolius, Lapw.
9. Glossograptus ciliatus, Emmons.
10. Corynoides, sp.

XLII. Bolton. A small collection—marked "loose"—probably from lot 6, range XIII. of Bolton, west side of Lake Memphremagog, Que.

1. Climacograptus bicornis, Hall.
2. Diplograptus foliaceus, Murchison.
3. " angustifolius, Lapw.

XLIII. Drummondville, Que. Collected by a member of the Geological Survey Staff, 1863. In a rusty weathering indurated graptolitic shale.

1. Leptograptus, sp.
2. Dicellograptus sextans, Hall.
3. Climacograptus, sp., *cf.* C. bicornis, Hall.
   " " " var. scalaris.
4. (?) Dendrograptus simplex, Walcott.
5. Leptobolus, sp., or a closely related genus of small brachiopod, too imperfectly preserved and irregularly compressed to be identified with certainty.

XLIV. Farnham Centre, Lot 26, Range I, Que. ; T. C. Weston, 1872. In a dark blue indurated limestone, weathering brown.

1. Obscure specimen of what appears to be *BolboporitesAmericanus*, Billings.

Bryozoa :

2. Pachydictya, sp. A diminutive form of the genus.

Brachiopoda :

3. Lingula, sp., *cf.* L. Iole, Billings, or allied species. This form may eventually prove to be a *Schizambon.*

4. Small Orthis-like or leptænoid shell, with two distinct kinds of longitudinal costæ. Fifteen (15) larger radiating costæ from the beak to the outer margin, and smaller and more numerous costæ between these larger ones—usually four in number between two of the larger costæ counted along the outer margin. Genus and species not determined. A diminutive form allied to Leptæna.

5. Orthis, sp., resembling O. delicatula, Billings.

Trilobita :

6. Ampyx Halli, Billings. Very small form. Cephalon, ·5 mm. in breadth, and ·85 mm. in length.

XLV. Farnham, Que., Lot 26, Range I. ; J. Richardson, 1861. In a dark blue indurated brown weathering limestone.

Brachiopoda:

1. Obolelloid shell. Generic relations obscure.

2. Leptæna, sp. A smooth variety which resembles L. sordida, Billings, and L. lævissima, McCoy, in "Synopsis of Silurian fossils of Ireland," p. 27, pl. iii, fig. 7, 1846. A. Leptella.

3. Leptæna, sp., *cf. Orthis quinquecostata,* McCoy, p. 33, pl. iii, fig. 8 of "Synopsis of the Silurian fossils of Ireland," McCoy, 1846, and subsequently described as Leptæna quinquecostata, McCoy. Length of hinge line in Farnham specimen = 1·25 mm. Possibly Leptella.

4. Leptæna, sp. Probably a Plectambonites, like P. sericea, (Sowerby).

5. Strophomena, sp., resembles very closely "*Orthis undulata,* McCoy" in his "Synopsis of the Silurian fossils of Ireland," p. 36, pl. iii, fig. 22, 1846.

6. Strophomena, *cf.* S. Aurora, Billings, but much smaller, apparently a diminutive form with coarse and fine striæ alternating.

7. Orthis, sp. *cf.* O. Electra, Billings. With rather strong radiating costæ. This form appears to be a true Dalmanella.

8. Orthis, *cf.* O. delicatula, Billings.

9. " sp., indt.

10. Rhynchonella or Camerella (Triplesia). Too imperfect for identification.

Cirripedia:

11. Turrilepas (?), sp.

Trilobita:

12. Triarthrus, sp.; *cf.* T. Fischeri, Billings, or T. Angelini, Linnarsson.

13. Ampyx Halli, Billings.

14. Asaphus- or Illænus-like fragments, too imperfect for determination.

15. Lichas (?), sp. An obscure portion of the cephalic shield of a trilobite resembling this genus.

16. Dalmanites, sp., of the type of Dalmanites callicephalus, Green.

Ostracoda:

17. Leperditia, or Beyrichia, sp.

XLVI. Lot 41, ranges V. and VI., West Farnham, Que.; T. C. Weston, 1876. (Two collections, *A* and *B*).

A—In light-coloured rock and shales.

Gasteropoda:

1. Cast of the interior of a gasteropod, probably a Pleurotomaria or Holopea.

2. Ophileta (?) bella, Billings. Referable to the genus Euomphalus.

3. Lophospira (?), sp. indt. Portion of the last or body volution of a large gasteropod, *cf.* Lophospira Cassina, Whitfield.

4. Maclurea, sp.

Trilobita:

5. Illænus or Asaphus, sp. Too imperfect for identification.

B—In black rusty-weathering shales.

Echinodermata:

1. Crinoidal or cystidean fragments.

Brachiopoda:

2. Leptæna (?), sp. indt.

3. Orthis, sp. Too fragmentary for identification.

Trilobita:

4. Bathyurus, sp. A very diminutive form.

XLVII. Lot 41, Range V., Farnham, Que.; J. Richardson, 1861. In a compact, light-coloured limestone, made up of small irregularly-rounded pellets showing oolitic structure.

Gasteropoda:

1. Bucania, sp. Probably a new species. Not Bellerophon Palinrus. Umbilicus open with fairly sharp keel on back.

2. Maclurea, sp., *cf.* M. ponderosa, Billings. A very small but tolerably perfect cast of a species of Maclurea, in characters and proportions agreeing with M. ponderosa, Billings.

XLVIII. Lot 32, range III., Farnham, Que.; J. Richardson, 1861. Farnham Centre, Que.; T. C. Weston, 1872. In black, rusty, weathering and wrinkled shale.

Graptolitoidea:

1. Fragments of graptolite, genus and species undeterminable showing the hydrothecæ only on one side of the polypary. There are visible some sixty (60) hydrothecæ in the space of five (5) centimetres—two and two-thirds ($2\frac{2}{3}$) inches. The shale resembles that of Castle Brook, Lake Memphremagog.

XLIX. Road, Farnham Centre to Cowansville, $2\frac{1}{2}$ miles west of Cowansville, lot 26, range VI., Dunham, Que.; R. W. Ells, 1890. In a very coarse and hard bluish-gray limestone.

Echinodermata:

1. Crinoidal or cystidean fragments.

Brachiopoda:

2. Leptæna (Plectambonites) sp. Fragment.

3. Orthis, type of Dalmanella testudinaria Dalman. A very small and diminutive form.

Trilobita:

4. Asaphus or fragment of asaphoid trilobite.

5. Illænus, sp., pygidium, not unlike the pygidium of Illænus Bayfieldi, Billings. Note—Also an obscure bryozoary allied to *Ptilodictya.*

L. Allan's Corners, Que.; R. W. Ells, 1890.

Echinodermata:

1. Crinoidal fragments similar to those found in preceding locality (lot 26, R. VI., Dunham, Que.).

Bryozoa:

2. Ptilodictya, sp., or allied genus.

Brachiopoda:

3. Leptæna (Plectambonites) sp. like P. sericea, Sowerby.
4. Leptæna decipiens, Billings. (=Leptella decipiens, Hall).
5. Orthis (Dalmanella) testudinaria, Dalman.
6. Triplesia, sp., *cf.* T. calcifera, Billings. A small and diminutive variety of the above.

Trilobita:

7. Asaphus, sp.
8. Dalmanites, sp.

LI. Lot 26, range I., East Farnham, Que.; Geological Survey collection.

The following notes were prepared by the late Mr. E. Billings.

"The fossils of the Farnham limestones are for the most part in a fragmentary condition, and not determinable specifically. The following genera have, however, been recognized:—

"1. *Graptolithus.* A species closely resembling G. bryonoides of the Lévis.

"2. *Ptilodictya,* like *P. acuta* of the Trenton. This genus is unknown below the Chazy.

"3. *Stenopora.* This genus ranges from the Lévis upwards.

"4. *Orthis.* Ranges from the Menevian upwards.

"5. *Leptæna.* One species, L. decipiens, occurs in the Lévis.

"6. *Ampyx.* Ranges from the Lévis upwards.

"7. *Dalmanites.* Not known below the Trenton.

"8. *Lichas.* Lévis upwards.

"9. *Triarthrus.* Lévis upwards.

"10. *Trinucleus.* Not known below the Trenton.

"11. *Agnostus.* Occurs in the Lévis and older rocks in America. In Europe, somewhat higher.

"The following are the peculiarities of this collection :—

"The genera of trilobites characteristic of the Lévis are absent. The genera (of trilobites) that do occur, are those of the higher rocks. The brachiopoda are more like those of the Trenton than those of the Quebec group. *Ptilodictya* and *Stenopora* are also types that had their greatest development after the general fauna of the Lévis became extinct. The graptolite is of a type characteristic of the Lévis and of the Skiddaw slates. The *Agnostus* is one of a type that ranges from the Lower Silurian downwards.

"The most curious character is that of the two genera (*Agnostus* and *Graptolithus*) which are common in the Lévis, and represented by full-sized individuals. But all those characteristic of the higher rocks are minute. The trilobites when perfect were mostly not more than three or four lines in length. This may be thus accounted for. It is known that on their first appearance many genera and even families consist of only very small species. The Trenton forms at Farnham, therefore, may be the ancestors of the species that afterwards came in. The fossils thus far collected, at this locality, furnish no evidence whatever that the rock is older than the Lévis, but rather that it is a stage more recent than the limestone of Point Lévis and Phillipsburg."

"E. B."

LII. Clarenceville, Que., range III., one mile and a half west of village, on the road from Lacolle, Que. ; R. W. Ells and W. E. Deeks, 12th June, 1891. (Range III., Township of Foucault, Que., between Richelieu River and Missisquoi Bay.)

Graptolitoidea :

1. Diplograptus foliaceus, Murchison.
2. " angustifolius, Hall.
3. " pristis (?), Hisinger (as of Hall).
4. Dicranograptus ramosus, Hall.
5. Climacograptus bicornis, Hall.

LIII. Lot 20, range V., Stanbridge, Que. ; about half a mile north of road to North Stanbridge, R. W. Ells, 1890. In a dark grayish-blue pyritiferous limestone.

Graptolitoidea :

1. Diplograptus, sp. An obscure graptolite referred with some doubt to the genus Diplograptus showing hydrothecæ, about ten (10) in the space of one centimetre.

2. Graptolite. A number of stipes which appear to show hydrothecæ only on one side of polypary, not determinable.

Brachiopoda :

3. Lingula, sp., of the type of L. Irene, Billings.

4. (?) Obolus? Murrayi, Billings.

5. Lingula, *cf.* L. Quebecensis, Billings, young individuals.

6. Leptella, sp. Like L. decipiens, Bill., or closely related thereto.

7. Orthis, sp. of the type of O. delicatula, Billings, but distinct when compared with Newfoundland specimens of O. delicatula. There are seen to be from 12 to 14 radiating lines with smaller ones intercalated.

8. Orthis (Dalmanella) sp. indt.

9. " sp. indt. A small form with ten (10) rather fine costæ of the type of *O. Ella.*

Gasteropoda :

10. Euomphalus, sp. The same form occurs in the Champlain Market rocks, Quebec City.

11. Scenella or Metoptoma, sp.

Pteropoda :

12. Hyolithes or Coleoprion, sp.

Trilobita :

13. Bathyurus-like trilobite, small head shield only preserved.

14. Asaphus, sp. Eye of Asaphus or closely related genus.

15. Illænus, sp. indt. pygidium.

16. " sp. Too imperfect for identification.

Ostracoda :

17. Isochilina or Polycope, sp. indt.

LIV. Shore, Missisquoi Bay, three-eighths of a mile south of Phillipsburg, Que. R. W. Ells, August, 1890.

Graptolitoidea :

1. Climacograptus, n. sp. (?)
2. " bicornis? Hall.
3. ? Dicranograptus sp.

TRENTON FORMATION.

BLACK RIVER DIVISION.

LV. Pointe Claire, Island of Montreal, Que.; collectors, Logan, E. Billings and G. Barnston, jr. (Geological Survey Museum, Ottawa):—

Zoophyta :

1. Columnaria Halli, Nicholson.

Pelecypoda :

2. Cyrtodonta subcarinata, Billings.

Gasteropoda :

3. Pleurotomaria Arachne, Billings.

Cephalopoda :

4. Actinoceras Bigsbyi, Stokes.

Trilobita :

5. Bathyurus extans, Hall.
6. Encrinurus vigilans, Hall.

LVI. Pointe Claire, old quarries for stone in piers of Victoria bridge, Jacques Cartier Co., Island of Montreal, Que. Peter Redpath Museum collection, McGill University, Montreal.

Hydroida :

1. Stromatocerium rugosum, Hall.

Zoophyta :

2. Tetradium fibratum, Safford.

Bryozoa :

3. Pachydictya acuta, Hall.

Brachiopoda :

4. Trematis Montrealensis, Billings.

Pelecypoda :

5. Cyrtodonta Huronensis, Billings.
6. " sp.

Gasteropoda :

7. Murchisonia perangulata, Hall.
8. Helicotoma larvata, Salter.

Cephalopoda :

9. Orthoceras multicameratum, Hall.
10. Gonioceras anceps, Hall.

Ostracoda :

11. Primitia leperditioides, Jones.

Trilobita :

12. Bathyurus extans, Hall.
13. Encrinurus vigilans (?), Hall.

LVII. One-eighth of a mile above the ferry, St. Vincent de Paul, Isle Jésus, Laval Co., Que. Collected by Dr. R. W. Ells and Mr. J. F. Whiteaves, 1895. Determined by Mr. Whiteaves in September, 1895.

Plantæ :

1. Licrophycus Ottawaënsis (?), Billings.

Hydroida :

2. Stromatocerium rugosum (?), Hall.

Zoophyta :

3. Tetradium fibratum, Safford.
4. Columnaria Halli, Nicholson.
5. Streptelasma corniculum, Hall.

Bryozoa :

6. Pachydictya acuta, Hall.

Crinoidea :

7. Glyptocrinus, stem fragments.

Brachiopoda :

8. Strophomena incurvata, Shepard.

Pelecypoda :

9. Cyrtodonta Huronensis, Billings.

Gasteropoda :

10. Murchisonia gracilis, Hall.

Cephalopoda :

11. Gonioceras anceps, Hall.
12. Actinoceras Bigsbyi, Stokes.
13. Cyrtoceras, several species.
14. Orthoceras "

TRENTON DIVISION.

LVIII. St. Dominique, Que. Higher beds, W. E. Deeks, 19th June, 1891.

Echinodermata :

1. Crinoidal or cystidean fragments.

Bryozoa :

2. Prasopora Selwyni, Nicholson* (= P. lycoperdon, Vanuxem).
3. Other species of Monticuliporoids requiring micro-sections.

Brachiopoda :

4. Discina or Trematis sp. Too imperfect for determination.
5. Orthis (Dalmanella) testudinaria, Dalman.
6. Orthis tricenaria, Conrad.
7. " sp.
8. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.

*Micro-section 2137, Geol. Surv. Can., prepared by Mr. T. C. Weston.

9. Strophomena incurvata, Shepard, Hall.
10. Rafinesquina alternata (Conrad), Emmons.
11. Plectambonites sericea, Sowerby.

Cephalopoda :

12. Orthoceras (?) sp.

Trilobita :

13. Trinucleus concentricus, Eaton.
14. Calymene senaria, Conrad.
15. Asaphus, sp.

LIX. St. Dominique, Que.; T. C. Weston, 1879, and J. Richardson, date not given. The rock is a sub-crystalline limestone traversed in many directions by white veins of calcite.

Bryozoa :

1. Prasopora Selwyni, Nicholson.
2. (?) Monotrypella Trentonensis, Nicholson.

Brachiopoda :

3. Orthis tricenaria, Conrad.
4. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.
5. Strophomena incurvata, Shepard.
6. Rafinesquina alternata (Conrad), Emmons.
7. Plectambonites sericea, Sowerby.

Trilobita :

8. Asaphus platycephalus, Stokes.
   (= Isotelus gigas. DeKay.)
9. (?) Encrinurus vigilans, Hall.

LX. St. Pie, Que.; Thos. C. Weston, 1879. In a dark gray impure limestone with white veins of calcite. Not classified :—Solenopora compacta, Billings.

Bryozoa :

1. Prasopora Selwyni, Nicholson.
2. (?) Monotrypella Trentonensis, Nicholson.

Brachiopoda :

3. Orthis (Dalmanella) testudinaria, Dalman.
4. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.
5. Rafinesquina alternata (Conrad), Emmons.
6. Plectambonites sericea, Sowerby.

Gasteropoda :

7. Bellerophon bilobatus, Sowerby.
8. Murchisonia gracilis, Hall.

Trilobita :

9. Calymene senaria ?, Conrad.
10. Asaphus platycephalus ?, Stokes.

LXI. Papineau Road range, two miles south of Abbottsford, Que., one-eighth of a mile west of railway between Abbottsford and L'Ange Gardien ; R. W. Ells. Two collections.

A.

Echinodermata :

1. Crinoidal fragments.

Bryozoa :

2. Prasopora Selwyni, Nicholson.
3. Pachydictya acuta, Hall.

Brachiopoda :

4. Lingula riciniformis ?, Hall.
5. Orthis (Dalmanella) testudinaria, Dalman sp.
6. Platystrophia biforata, Schlotheim, var. lynx, Eichwald.
7. Rafinesquina alternata (Conrad), Emmons.
8. Plectambonites sericea, Sowerby.

Cephalopoda :

9. Endoceras proteiforme, var. tenuistriatum, Hall.
10. Orthoceras bilineatum, Hall.

Trilobita :

11. Trinucleus concentricus, Eaton.
12. Calymene senaria, Conrad.
13. Asaphus platycephalus, Stokes.

B.

LXII. Papineau Road, two miles south of Abbottsford, Que., near railway crossing ; R. W. Ells, 1890. In a black unevenly bedded and somewhat indurated limestone :—

Brachiopoda :

1. Plectorthis plicatella (Orthis), Conrad.
2. Dalmanella testudinaria (Orthis), Dalman.
3. Orthis tricenaria, Conrad.

LXIII. Highgate Springs, Vermont (near Canadian boundary line). H. M. Ami and R. W. Ells, 1883.

Bryozoa :

1. Pachydictya acuta, Hall.

2. Prasopora Selwyni, Nicholson.
3. Other monticuliporoidea requiring micro-sections.

Brachiopoda :

4. Orthis (Dalmanella) testudinaria, Dalman.
5. Orthis (Plectorthis) plicatella, Conrad.
6. Orthis (Dinorthis) pectinella, Emmons.
7. Rafinesquina alternata (Conrad), Emmons.
8. Strophomena incurvata, Shepard.
9. Rhynchotrema inæquivalvis, Castelnau.
   (= Rhynchonella increbescens, Hall.)
10. Plectambonites sericea, Sowerby.

Gasteropoda :

11. Bellerophon bilobatus, Sowerby.
12. Raphistoma lapicida, Salter.

Pteropoda :

13. Conularia Trentonensis, Hall.

Cephalopoda :

14. Orthoceras arcuoliratum, Hall.
15. 16. Orthoceras, two species as yet undetermined.

Trilobita :

17. Trinucleus concentricus, Eaton.
18. Calymene senaria, Conrad.
19. Asaphus megistos, Locke.
20. Harpes Ottawäensis, Billings.

LXIV. Mile-End Quarries, &c, Island of Montreal, Hochelaga County, Que. Classified list of species compiled from various sources.

Asteroidea :

1. Edrioaster Bigsbyi, Billings.

Cystoidea :

2. Pleurocystites squamosus, Billings.
3. " exornatus, Billings.
4. Glyptocystites Logani, Billings.
5. " " var. gracilis, Billings.
6. " multiporus, Billings.

Crinoidea :

7. Dendrocrinus acutidactylus, Billings.
8. " proboscidiatus, Billings.
9. " cylindricus, Billings.
10. Heterocrinus Canadensis, Billings.
11. " tenuis, Billings.

12. Archæocrinus pyrifomis, Billings, sp.
13. Cleiocrinus grandis, Billings.

Bryozoa:

14. Subretepora reticulata, Hall (= Intricaria reticulata, Hall, of former reports).
15. " Dawsoni, Ulrich.
16. Protocrisina exigua, Ulrich.
    (= Gorgonia? perantiqua, Hall.)
17. Phylloporina Trentonensis, Nicholson.
18. Pachydictya acuta, Hall.
19. " triserialis, Ulrich.
20. Phænopora incipiens, Ulrich.
21. Nematopora ovalis, Nicholson.
22. Arthronema tenue, James sp.
23. Amplexopora superba, Foord.
24. Prasopora Selwyni, Nicholson.

Brachiopoda:

25. Lingula quadrata, Eichwald.
26. " Kingstonensis, Billings.
27. " riciniformis, Hall.
28. " Progne, Billings.
29. " Daphne, Billings.
30. " Philomela, Billings.
31. Schizotreta Pelopea. (= Discina Pelopea, Billings).
32. Orbiculoidea lamellosa, Hall (= Discina Circe, Billings).
33. Trematis terminalis, Emmons.
34. " Montrealensis, Billings.
35. Orthis (Plæsiomys) subquadrata, Hall.
36. " (Dalmanella) testudinaria, Dalman.
37. " (Dinorthis) pectinella, Emmons.
38. Platystrophia biforata, var. lynx, Eichwald.
39. Rafinesquina deltoidea, Conrad sp.
40. " alternata, (Conrad) Emmons.
41. Plectambonites sericea, Sowerby.
42. Rhynchotrema inæquivalvis, Castelnau.
43. Zygospira recurvirostra, Hall.
44. " deflecta, Hall.
45. Anastrophia hemiplicata, Hall.

Pelecypoda:

46. Avicula Hermione, Billings.

47. Modiolopsis carinata, Hall.
48. " faba, Conrad.
49. Ctenodonta dubia, Hall.
50. " nasuta, Hall.
51. " astartæformis, Salter.
52. Ambonychia bellistriata, Hall.

Gasteropoda:

53. Ecculiomphalus Trentonensis, Conrad.
54. Cyrtolites compressus, Emmons.
55. Bellerophon bilobatus, Sowerby.
56. Trochonema umbilicatum, Hall.
57. Cyclonema Montrealense, Billings.
58. " Hageri, Billings.
59. Holopea symmetrica, Hall.
60. " Nereis, Billings.
61. Subulites subfusiformis, Hall.
62. Metoptoma Trentonensis, Billings.
63. Conularia Trentonensis, Hall.
64. Murchisonia gracilis, Hall.
65. Pleurotomaria Americana, Billings.

Cephalopoda:

66. Orthoceras strigatum, Hall.
67. " bilineatum, Hall.
68. Cyrtoceras Juvenale, Billings.
69. " macrostomum (?), Hall.
70. Endoceras proteiforme, Hall.
71. " " var. lineolatum, Hall.

Vermes:

72. Serpulites dissolutus, Billings.
73. Cornulites flexuosus, Hall.

Trilobita:

74. Trinucleus concentricus, Eaton.
75. Calymene senaria, Conrad.
76. Cheirurus pleurexanthemus, Green.
77. Asaphus platycephalus, Stokes (= Isotelus gigas, DeKay).

Ostracoda;

78. Leperditia Canadensis, var. nana, Jones.

LXV. Joliette, County of Joliette, L'Assomption River, Que.; collector, H. M. Ami, 1881.

Graptolitoidea:

1. Diplograptus, *cf.* D. putillus, Hall.

Bryozoa :

2. Pachydictya acuta, Hall.
3. " sp. indt.
4. Ptilodictya maculata, Ulrich.
5. Monotrypella Trentonensis, Nicholson.
6. Prasopora Selwyni, Nicholson.
7. Amplexopora Canadensis, Foord.
8. Solenopora compacta, Billings. (Zoological affinities in question.)

Crinoidea :

9. Glyptocrinus ramulosus, Billings.

Brachiopoda :

10. Orthis (Plectorthis) plicatella, Conrad.
11. " (Dalmanella) testudinaria, Dalman.
12. Rafinesquina alternata, (Conrad) Emmons.
13. Plectambonites sericea, Sowerby.

Pteropoda :

14. Conularia Trentonensis, Hall.

Gasteropoda :

15. Cyclonema bilix, Hall.
16. Trochonema umbilicatum, Hall.
17. Pleurotomaria Progne, Billings.

Cephalopoda :

18. Endoceras proteiforme, Hall.
19. " multitubulatum, Hall.

Vermes :

20. Serpulites dissolutus, Billings.

Trilobita :

21. Calymene senaria, Conrad.
22. Asaphus platycephalus, Stokes.
23. Illænus, *cf.* I. Milleri, Billings.
24. Cheirurus pleurexanthemus, Green.

LXVI. Joliette, Canadian Pacific Railway quarry, between the two bridges on L'Assomption River, Joliette County, Que.; collector, N. J. Giroux, October, 1892:—

Graptolitoidea :

1. Diplograptus or Climacograptus, too imperfect for identification.

Bryozoa :

2. Amplexopora or Batostoma sp.
3. Pachydictya acuta, Hall.

4. Ptilodictya maculata, Ulrich.
5. Solenopora compacta, Billings.

Brachiopoda :

6. Lingula Philomela (?), Billings.
7. " or Discina sp., too imperfect for identification.
8. Orthis (Dalmanella) testudinaria, Dalman.
9. Orthis tricenaria (?), Conrad.
10. Rafinesquina alternata (Conrad), Emmons.
11. Strophomena incurvata, Shepard.

Pteropoda :

12. Conularia quàdrata, Walcott, or allied species.
13. " Trentonensis, Hall.

Trilobita :

14. Acidaspis spiniger, Hall.
15. Cheirurus pleurexanthemus, Green.
16. Asaphus platycephalus, Stokes.
17. Illænus Milleri, Billings.

UTICA FORMATION.

XLVII. Clarenceville, Que., range IV., ridge east of the village; R. W. Ells and W. E. Deeks, 12th June, 1891.

Spongiæ :

1. ? Cyathophycus reticulatus, Walcott.

Graptolitoidea :

2. Climacograptus, sp.
3. Orthograptus quadrimucronatus, Hall.

Cephalopoda :

4. Endoceras proteiforme, Hall.
   (? = Orthoceras lamellosum, Hall).

Trilobita :

5. Triarthrus sp., *cf.* T. glaber, Billings.
6. " Becki, Green.

LXVIII. Lacolle, Que., half a mile east of the village, in river along side of road to Grand Trunk station. R. W. Ells and W. E. Deeks, 12th June, 1891.

Graptolitoidea :

1. Climacograptus, sp. Same form also occurs at Holland Patent, N.Y., and is referable to C. bicornis, Hall, by most writers.

2. Diplograptus mucronatus (?), Hall.

Brachiopoda :

3. Plectambonites sericea, Sowerby.

Trilobita :

4. Triarthrus Becki, Green.

LXIX. Lacolle, Que.; one-eighth of a mile west of the Richelieu River bridge, 12th June, 1891. R. W. Ells and W. E. Deeks.

Graptolitoidea :

1. Orthograptus quadrimucronatus, Hall.

Trilobita :

2. Triarthrus Becki, Green.

LXX. Montreal ; below piers, at low water, north end of Victoria Bridge, Point St. Charles. Collector, Thos. Curry, 1891.

Graptolitoidea :

1. Dendrograptus simplex, Walcott.
2. Reteograptus ? Eucharis, Hall.
3. Orthograptus quadrimucronatus, Hall.
4. Climacograptus Scharenbergi (?) Lap.

Cephalopoda :

5. Endoceras proteiforme, Hall.

Trilobita :

6. Triarthrus Becki, Green.

LXXI. Montreal, Que.; also collected by Thos. Curry, on the western extremity of St. Helen's Island, and at low water in the harbour, from blocks obtained in dredgings by Public Works Department.

Graptolitoidea :

1. Climacograptus sp.
2. Leptograptus flaccidus, Hall.
3. Diplograptus sp.

Brachiopoda :

4. Leptobolus insignis.
5. Orthis (Dalmanella) testudinaria, Dalman.

Vermes :

6. Cornulites immaturum, Hall.

Cephalopoda.

7. Orthoceras lamellosum, Hall.

LORRAINE FORMATION.

LXXII. Chambly, Que. W. E. Deeks, 1890.

Echinodermata:

1. Crinoidal fragments.

Graptolitoidea :

2. (?) Orthograptus quadrimucronatus, Hall.

Brachiopoda :

3. Pholidops subtruncatus, Hall.
4. Rafinesquina alternata, (Conrad) Emmons.
5. Streptorhynchus Trentonensis, Winchell and Schuchert.
6. Leptæna (Plectambonites) sericea, Sowerby. Two varieties of this species occur in the collection.
7. Rhynchotrema inæquivalvis, Castelnau, sp.
8. Zygospira Headi, Billings.

Pelecypoda :

9. Pterinea demissa, Conrad.
10. Lyrodesma pulchellum, Emmons.
11. Orthodesma pholadis (?), Conrad.
12. Modiolopsis curta, Hall.*
13. " faba, Conrad.
14. Ambonychia (Byssonychia) radiata, Hall.

Gasteropoda :

15. Bellerophon bilobatus, Sowerby.
16. Murchisonia gracilis, Hall.
17. " Milleri, Hall.

Trilobita :

18. Calymene, sp. indt.
19. Illænus, sp. indt.
20. Proëtus, sp.

LXXIII. St. Hyacinthe, Que. ; W. E. Deeks, 1891 :—

Echinodermata :

1. Crinoidal stems and fragments.

Hydromedusæ :

2. (? ?) Sagenella ambigua, Walcott, parasitic on the shell of an orthoceratite.
3. Orthograptus quadrimucronatus, Hall.

---

*Also Clidophorus planulatus, Conrad, and a species of Climacograptus.

Bryozoa :

4. Monticuliporoidea, requiring micro-sections.

Brachiopoda :

5. Lingula, sp. indt.
6. Orthis (Dalmanella) testudinaria, Dalman.
7. Leptæna (Plectambonites), sp.
8. Rhynchotrema inæquivalvis, Castelnau.
9. Zygospira modesta, Say.

Pelecypoda :

10. Clidophorus planulatus.
11. Nucula levata, Hall.
12. Modiolopsis curta, Hall.
13. " faba, Conrad.
14. " modiolaris (?), Conrad.
15. Lyrodesma post-striatum, Emmons.
16. Orthodesma pholade, Conrad.

Gasteropoda :

17. Cyrtolites ornatus (?), Conrad.
18. Bellerophon bilobatus, Sowerby.
19. Trocholites, sp.

Cephalopoda :

20. Endoceras proteiforme, Hall, probably Orthoceras lamellosum, Hall.

Trilobita :

21. Trinucleus, sp. Portion of the ornamented border around the cephalic shield.
22. Triarthrus, sp., *cf.* T. Becki, Green.

LXXIV. Yamaska River, one mile and a half below the mouth of Servailles River, near St. Hyacinthe, Que. N. J. Giroux, 1890.

Echinodermata :

1. Crinoidal columns and other fragments.

Hydromedusæ :

2. (?) Alecto or other related genus.

Brachiopoda :

3. Lingula, sp.
4. Pholidops subtruncatus, Hall.
5. Orthis (Dalmanella) testudinaria, Dalman.
6. Orthis (Dinorthis) pectinella, Conrad.
7. Orthis (Plectorthis) plicatella, Hall.
8. Rafinesquina alternata, (Conrad) Emmons.

9. Strophomena Trentonensis, Winchell & Schuchert).
10. Plectambonites sericea, Sowerby.
11. Rhynchotrema inæquivalvis, Castelnau.

Pelecypoda :

12. Modiolopsis, sp.
13. Ambonychia (Byssonychia) radiata, Hall.

Gasteropoda :

14. Cyrtolites, sp.

Cirripedia :

15. Turrilepas (?), sp.

Trilobita :

16. Trinucleus concentricus (?), Eaton. Possibly a new form.
17. Triarthrus (?), sp. indt.
18. Calymene senaria, Conrad.
19. Asaphus megistos, Locke.

LXXV. Rougemont, Que. ; Thos. Curry, 1872.

Echinodermata :

1. Crinoidal fragments.

Brachiopoda :

2. Lingula curta (?), Hall.
3. Pholidops subtruncatus, Hall.
4. Orthis (Hebertella) occidentalis, Hall.
5. (Dalmanella) testudinaria, Dalman.
6. Plectambonites sericea, Sowerby.
7. Rafinesquina alternata, (Conrad) Emmons.
8. Strophomena nitens, Billings.
9. Zygospira Headi, Billings.

Pelecypoda :

10. Orthodesma parallelum, Hall.
11. Clidophorus planulatus, Conrad.
12. Orthodesma pholade Hall.
13. Pterinea demissa, Conrad.

Gasteropoda :

14. Bellerophon bilobatus, Sowerby.
15. Cyclonema ?? sp. indt.
16. Cyrtolites ornatus, Conrad.

Trilobita :

17. Calymene senaria, Conrad.
18. Asaphus sp.

LXXVI. River des Hurons, Que. T. Curry, 1872.

Pelecypoda :

1. Ambonychia (Byssonychia) radiata, Hall, sp.
2. Pterinea demissa, Conrad.
3. Modiolopsis modiolaris, Conrad.
4. " anodontoides, Conrad.
5. " pholadiformis, Hall.
6. Clidophorus planulatus, Conrad.
7. Orthodesma parallelum, Hall.

Trilobita :

8. Triarthrus Becki, Green.
9. Asaphus megistos, Locke.

SILURIAN FOSSILS.

LXXVII. North Stoke, Que. H. M. Ami and R. W. Ells, 1886. (Not previously published. S. E. Sheet.)

Zoophyta :

1. Favosites Gothlandicus, Lamarck. The corallites in these specimens measure a trifle over two (2) millimetres each, five corallites in the space of a little over ten millimetres. The largest corallites measure three (3) millimetres.

2. Favosites, with much smaller corallites than sp. No. 1, *cf. F. Helderbergiæ*, Hall. Aperture or breadth of each corallite about one millimetre, or ten corallites in the space of one centimetre.

3 Syringopora, sp. indt.

4. Zaphrentis, sp. About forty (40) radiating lamellæ in the circumference of the polyp.

Echinodermata :

5. Crinoidal fragments. Both large and small fragments, probably referrable to two distinct species.

Brachiopoda :

6. Obscure markings like the spiral supports of Atrypa reticularis.

7. Obscure cast of Spirifera, *cf.* S. Niagarensis, but smaller than Ontario or New York representatives of that species.

Gasteropoda :

8. Straparollus, sp. Three volutions—one large and two much smaller. Shows also the nepionic stage of the shell, &c., with measurements as follows:—

(1.) Embryonic shell, 1 mm. across.
(2.) 1st volution 3 " "
(3.) 2nd " 8 " "
(4.) 3rd or body volution 15 mm. across.

The specimen is preserved as a mould of the exterior or possibly as a mould of the cast of the interior of the shell.

LXXVIII. "Georgeville," Que.; A. Webster, 1879 :—

Zoophyta :

1. Halysites catenularia, Linnæus.
2. Favosites Gothlandicus, Lamarck. A tolerably well preserved specimen, showing the mural pores, &c.; resembles the form occurring near Tuck's Landing, Sargent's Bay, on the west side of the lake.
3. Favosites, sp., *cf.* F. favosus, Goldfuss. With exceptionally large corallites.
4. Zaphrentis, sp.

Echinodermata :

5. Fragments of crinoidal columns.

LXXIX. Capt. Gully's point, opposite Owl's Head, Lake Memphremagog, Que.; Ells, 1890.

Hydroida :

1. Stromatoporoid (undetermined).

Zoophyta :

2. Favosites Gothlandicus, Lamarck.
3. " with smaller corallites, and resembling F. Helderbergiæ, Hall.

LXXX. Round Island, Lake Memphremagog, Que.; Ells, July, 1890 (in a dark gray glossy pyritiferous calc-schist; obscure fossils).

1. Stromatopora, sp.
2. Heliolites, sp. Very imperfectly shown.
3. Favosites, sp. indt.

LXXXI. Knowlton Landing, Que.; Ami, 1886, (now known as Tuck's Landing P.O., Que.), Sargent's Bay, Lake Memphremagog, Que. :—

Plantæ :

1. Psilophyton, sp.

Zoophyta :

2. Favosites Gothlandicus, Lamarck

Bryozoa :

3. Polypora or Monticuliporoid.

Brachiopoda :

4. Rhynchonella, sp.; type of R. Wilsoni, Sowerby.

LOWER HELDERBERG DIVISION.

LXXXII. St. Helen's Island, St. Lawrence River, opposite Montreal (Dawson collection ; Peter Redpath Museum of McGill University) :—

Besides numerous fragments of crinoidal columns, &c.

Zoophyta :

1. Favosites, *cf.* F. Gothlandicus, Lamarck.
2. " resembling F. Helderbergiæ, Hall.
3. " ? sp. indt
4. Pachypora ? sp.
5. ? Zaphrentis sp. No. 1.
6. " sp. No. 2.
7. Undetermined cyathophylloid coral.

Bryozoa :

8. Callopora or Calloporella sp.
9. Polypora, *cf.* P. perangulata, Hall.
10. Fenestella (?) sp. indt.
11. Ptilodictya ? sp.

Brachiopoda :

12. Chonetes, *cf.* C. melonica or n. sp.
13. Orthis, probably Orthis (Rhipidomella) eminens, Hall.
14. Orthis (Rhipidomella) oblata, Hall.
15. " resembling somewhat Orthis (Orthostrophia) strophomenoides, Hall.
16. Strophonella punctulifera, Conrad.
17. " cavumbona, Hall.
18. Strophodonta varistriata, Conrad, showing tendency towards var. arata.
19. Strophodonta varistriata, Conrad. Var. This form is more strongly arcuate than the type specimens figured.
20. ? Strophodonta Becki, Hall or Streptorhynchus Woolworthanum, Hall.
21. Leptagonia rhomboidalis, Wilckens.
22. Strophomenoid shell resembling somewhat Streptorhynchus radiatum, Vanuxem.

23. Spirifera concinna, Hall.
24. " " (large variety).
25. " *cf.* S. Cumberlandiæ, Hall.
26. " n. sp. (?); also another of the type of S. arenosa, Conrad.
27. " cycloptera, Hall.
28. " sp. with from eighteen to twenty costæ on each side of the mesial sinus. General appearance very much like S. pennata (=S. mucronata), not quite so arcuate and the concentric lines of growth are not so strongly lamellose or rugose.
29. Spirifera, *cf.* S. perlamellosa, Hall.
30. Atrypa reticularis, Linnæus.
31. Trematospira multistriata, Hall, or closely related species.
32. ? Leiorhynchus, sp. indt. Unlike L. multicostum, Hall.
33. Rhynchonella abrupta, Hall.
34. Rhynchonella, *cf.* R. acutiplicata, Hall.
35. " æquivalvis (?), Hall, possibly a Rensselæria.
36. " formosa, Hall. Since referred to the genus Stenoschisma.
37. " nucleolata, Hall.
38. " nobilis, Hall. One of the specimens found in conjunction with this species bears a strong resemblance to *R. Campbellana*, Hall.
39. Rhynchonella pleiopleura or multistriata of Hall.
40. Rhynchonella ventricosa, Hall.
41. Eatonia sinuata, Hall, or a closely related species.
42. Pentamerus galeatus, Dalman.
43. " pseudogaleatus, Hall.

Pelecypoda:

44. Pterinea, sp., *cf.* P. textilis, Hall. A small variety.

Gasteropoda:

45. Platyostoma depressum, Hall.

DEVONIAN FOSSILS.

LXXXIII. Sargent's Bay, Lake Memphremagog, west side. Collected by H. M. Ami, 1894.

Spirophyton cauda-galli, Vanuxem. This plant is sometimes referred to the genus *Taonurus*, and as a rule characterizes a special horizon in the Helderberg Mountains of New York State and elsewhere. It has been met with in Eastern Quebec and New Brunswick. At this locality the flag stones on which this species occurs abundantly

are inclined at right angles to the horizon along the side and bed of a small stream which flows into the bay about three-quarters of a mile above Tuck's Landing.

LXXXIV. Owl's Head, Lake Memphremagog, Que. From the Devonian limestone "belts" referred to by Sir Wm. Logan and Mr. E. Billings in the "Geol. of Canada, 1863," p. 436.

Hydroida :

1. Stromatopora concentrica, Goldfuss.

Zoophyta :

2. Favosites Gothlandicus, Lamarck.
3. " basalticus, Goldfuss.
4. " polymorpha, Goldfuss.
5. Zaphrentis, sp. indt.
6. Heliophyllum, sp. indt.
7. Diphyphyllum arundinaceum, Billings.
8. Syringopora Hisingeri, Billings.

Echinodermata :

9. Crinoidal fragments.

Geological Survey Department,
Ottawa September 20th, 1895.

GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C. M. G., L.L.D., F. R. S., Director

REPORT

ON THE

SURFACE GEOLOGY

OF

EASTERN NEW BRUNSWICK, NORTH-WESTERN NOVA SCOTIA

AND A PORTION OF

PRINCE EDWARD ISLAND

TO ACCOMPANY ¼ SHEET MAPS, NO. 2 S.E., NO. 5 S.W. AND NO. 4. N.W.

BY

ROBERT CHALMERS, F.G.S.A.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1895

To Dr. G. M. Dawson, C.M.G., F.R.S., Etc.,

Director of the Geological Survey of Canada,

Ottawa.

Sir,—Herewith I beg to present you my report on the Surface Geology of eastern New Brunswick, north-western Nova Scotia, and a portion of Prince Edward Island, accompanied by the three quarter-sheet maps No. 2 S.E., No. 5 S.W. and No. 4 N.W. illustrative thereof. The report embraces the results of the field-work carried on during the four seasons of 1890, 1891, 1892 and 1893.

Permit me to express my sincere thanks to the gentlemen named below for assistance and various acts of kindness:—To P. S. Archibald, Chief Engineer of the Intercolonial railway, and his assistant, W. B. Mackenzie, C.E., for maps, plans and profiles, and for valuable information at all times cordially given; to J. R. Cowan, Manager of the Cumberland Railway and Coal Company, for permission to copy the profiles of the Springhill and Parrsboro' railway; to H. G. C. Ketchum, C.E., for important information respecting the Chignecto Marine Transport railway, and for the results of observations on the tides of Cumberland Basin, at the head of the Bay of Fundy, and of Baie Verte in Northumberland Strait. To Dr. Thomas Harrison, President of the University of New Brunswick, J. F. Connors, Chatham, and Arthur Newbury, Charlottetown, P.E.I., I am indebted for barometric readings taken at the respective meteorological stations under their charge. W. C. Milner, Collector of Customs, Sackville, and B. E. Paterson, of the Amherst *Press*, formerly of the Chignecto *Post*, have placed me under obligations for data relating to the salt marshes at the head of Cumberland Basin; and W. H. Crosskill, of the Legislative Library, Charlottetown, kindly presented me with reports and papers treating of the geology and natural resources of Prince Edward Island. To the many other friends who have, year after year, aided me in the prosecution of my work, but whom it would be impossible to name here, I desire to offer my grateful acknowledgments.

I have the honour to be, sir,

Your obedient servant,

ROBERT CHALMERS.

Ottawa, January, 1895.

NOTE.—The bearings given in this report are all referred to the true meridian, and the elevations to mean tide level, unless otherwise stated.

REPORT

ON THE

SURFACE GEOLOGY

OF

EASTERN NEW BRUNSWICK, NORTH-WESTERN NOVA SCOTIA

AND A PORTION OF

PRINCE EDWARD ISLAND

TO ACCOMPANY $\frac{1}{4}$ SHEET MAPS, NO. 2 S.E., NO. 5 S.W. AND NO. 4 N.W.

BY ROBERT CHALMERS, F.G.S.A.

INTRODUCTION.

Area covered

The following report embodies the results of the surveys and explorations carried on by me in Northumberland, Kent, Westmoreland and Albert counties, New Brunswick ; Cumberland county, Nova Scotia ; and the central part of Prince Edward Island, during the seasons of 1890-91-92-93. These areas embrace one of the most interesting and important fields of investigation to be found in eastern Canada, both as regards their surface geology and their agricultural resources, and present to the student a great variety of questions for correlation and study. The detailed work described in these pages has resulted in the discovery of a large number of facts, many of them new, especially those showing the relative effects of land ice and floating ice in the Pleistocene period, which are better exemplified in this region, perhaps, than elsewhere on the coasts of North America. The eastern and south-eastern limits of the land ice which covered that portion of Canadian territory lying south of the valley of the St. Lawrence River, between

Results of investigations.

Gaspé and the Bay of Fundy, were traced out approximately and defined. The conclusion that the ice-limits in this direction were unaccompanied by terminal moraines will be presented and facts adduced showing the probable cause of such conditions. An attempt will also be made to define the dimensions of the several local glaciers which occupied the country in the ice age, as far as the data at hand enable me to do so ; and their connection and relation to the larger ice-sheets which had their sources in the Appalachian Range to the north-west will be pointed out. Data demonstrating beyond question the existence and action of floating ice in the Pleistocene were obtained, and will receive adequate treatment in this report. Changes of level during the later Tertiary and Post-Tertiary periods, which within the last decade have been much discussed, were carefully investigated; shore-lines were levelled in a great number of places and a body of facts obtained which will elucidate this question with more accuracy of detail than has yet been attempted. The region offered special advantages for a study of this kind and the results, it is hoped, are of value. The physical features and remarkable tides of the Bay of Fundy were considered worthy of special study and some space will be devoted to a discussion and explanation of their origin. The wide dispersion of boulders from the higher to the lower grounds, and occasionally in a contrary direction, is a subject which also received careful inquiry. The distribution of crystalline boulders from the central highlands of New Brunswick over the whole Carboniferous plain to the east, and upon the western part of Prince Edward Island came under observation and will be discussed in the sequel. The occurrence of sandstone boulders on the summit of the Cobequid Mountains, apparently derived from the Carboniferous plain on the north, from 200 to 400 feet lower, was a problem to which we also endeavoured to find a solution. Horse-backs, osar, or kames, of which there are some good examples in the maritime provinces, were studied in their relation to the Pleistocene drift, to the drainage of the respective districts in which they occur, and to post-glacial denudation, river-terraces, etc.

A considerable amount of field investigation has been bestowed upon the pre-glacial sands, gravels, angular boulders, etc., usually called residuary, which have been found in different parts of the region, and their relation to the glacial and post-glacial deposits traced as far as it was possible to do so. These materials are much more common than has hitherto been supposed. The dunes of sand which skirt the coast of the Carboniferous area on the mainland and the north-east side of Prince Edward Island, and are especially well developed around the

Magdalen Islands, have received special attention. One of the most important of the superficial deposits of the district around the head of the Bay of Fundy is the marine alluvium, known as salt marsh, the mode of formation and economic aspects of which were carefully investigated. Everywhere within the region under examination the character of the soil and its suitability to agriculture were noted, and close attention was also given to the forest growth, the area still covered by the original forest being mapped as accurately as possible.

In the examination of the surface geology of the areas under review, all accessible parts of the country were explored, every road travelled over, the hills and mountains ascended and their altitudes measured with aneroid or otherwise, rivers and lakes examined with canoe or on foot, and as careful and accurate an investigation of the superficial phenomena made as the means at my disposal and other circumstances would permit. Portions of country explored.

Photographs of glacial striæ, shore-lines, sections of the superficial deposits, etc., were taken during the seasons of 1892 and 1893, some of which exhibit the difference between striation produced by land ice and that produced by floating ice. Several remarkable sets from the Isthmus of Chignecto, the Cape Tormentine peninsula, and the Baie des Chaleurs district, show the diverse movements of the striating agent, and cannot have been produced by other than the latter agency. Glacial striæ shore lines, etc., photographs of.

In the field-work of the four seasons embraced in this report I was assisted by the gentlemen named below:—In 1890 by John H. McDonald, of Brockville, Ont., and for part of the season by Wm. J. Wilson; in 1891 by Mr. Wilson and W. D. Matthew, of St. John, N.B., but only for a few months; in 1892 Mr. Wilson was with me the whole season, and K. C. Cochrane, of Brockville, Ont., from the 20th of May till the 10th of September. In 1893 Mr. Wilson alone was my field assistant. Assistants.

The preparation of the maps for the engraver, quarter-sheets Nos. 2 S.E., 5 S.W. and 4 N.W., has been largely accomplished by W. J. Wilson. Maps.

The surface geology of those portions of New Brunswick and Nova Scotia included in this report were cursorily referred to by the writer and Dr. Ells in the reports of 1885, where partial lists of the striæ were published.*

The surface geology of Prince Edward Island is described in Dawson and Harrington's report.† Previous work in region

*Annual Report, Geol. Surv. Can., Vol. I. (N.S.), 1885. Parts E and GG.

†Report on the Geological Structure and Mineral Resources of P.E. Island, by Sir J. W. Dawson and Dr. B. J. Harrington, 1871.

Topographical and Physical Features.

Topographical features.

The topographical features of large portions of the mainland in the area under discussion are those of a flat and uninteresting plain. Where this area is occupied by Middle Carboniferous rocks, the surface has, in a general way, a slight descent toward Northumberland Strait, varied to some extent by low, wide undulations, the axes of which trend nearly east and west. In the isthmus of Chignecto and in those parts of Cumberland county, Nova Scotia, lying north of the Cobequid Mountains, the Upper Carboniferous rocks have a considerable development, and the east-and-west anticlinals and synclinals are narrower and more conspicuous, rendering the features of the country more pronounced. In some instances these irregularities have affected the drainage, but as a rule the larger rivers have taken courses independent of them. It is evident, however, that the Carboniferous rocks in the latter district (that is, those in proximity to the crystalline ridges of southern New Brunswick and the Cobequids in Nova Scotia,) have suffered more disturbance than they have in the central part of the great triangular basin. In Albert county, New Brunswick, the north-east prolongation of the crystalline ridge or plateau referred to, which stretches along the north-west side of the Bay of Fundy, rises in broken ridges and mountains to an altitude of 1,300 or 1,400 feet, Shepody Mountain, which was a station in the Admiralty Survey, being 1,050 feet high. The general slope of this elevated country is towards Shepody Bay; but the north-east extremity inclines towards the east, north-east and north-west. These highlands are, however, much denuded and trenched wherever the crystalline series are overlapped by Lower Carboniferous rocks. They have had an important influence on ice-movements in the Pleistocene period.

Albert county, N.B.

To the north of the Petitcodiac River, about six miles distant from Moncton, ridges or hills known as Lutz or Indian Mountain rise from the level Carboniferous plain to the height of 500 or 600 feet above the sea. At the head of the Bay of Fundy, between the estuary of the Petitcodiac and La Planche River, hills and ridges extending nearly east and west lie between the tongues of salt marsh running up the valleys of the Petitcodiac, Memramcook, Tantramar, Missaquash and La Planche rivers, which carry the drainage waters of the Isthmus of Chignecto into the head of the Bay of Fundy. None of these ridges exceed 400 or 500 feet in height. The strata are broken and faulted, evidencing disturbance and pressure from both sides, but principally from the side of the New Brunswick crystalline range above mentioned.

Head of Bay of Fundy.

In the part of Nova Scotia included in sheet No. 4, N.W. the Cobequid Range is the most prominent topographical feature. It extends in a nearly east-and-west direction along the north side of Minas Basin, with a width of nine or ten miles, and a height of 900 or 1,000 feet, some of the culminating peaks reaching probably 1,100 feet. Passes exist in some places, notably one at Halfway River, which is traversed by the Springhill and Parrsboro' railway, and others at Westchester and at Folly Lake, the latter the route of the Intercolonial railway. The bottom of the pass at Halfway River is only eighty-five feet above mean tide level; that at Folly Lake is 600 feet. Cobequid Mountains.

On the slope between the Cobequid Mountains and Northumberland Strait, a number of hills occur, besides the ridges or anticlinals referred to on page 8 M. Springhill, the summit of which is 610 feet above mean tide, is the highest; Claremont Hill to the east of Springhill is 565 feet high. These two lie near the northern base of the Cobequids, where the undulations or disturbances due to the uplift of the mountain range have been greatest and where ridges parallel thereto, such as Windham Hill, rise to altitudes of more than 600 feet. Further to the north rise the Maccan Mountains, the heights along the Leicester Road and Mount Pleasant, which attain altitudes of from 350 to 600 feet above the sea. These hills appear to have been local ice-sheds during the Pleistocene period. North slope of Cobequids.

Crossing Northumberland Strait to Prince Edward Island we find that it presents a more or less close repetition of the topographic features of the adjacent mainland. A large portion of the island is low, from two-thirds to three-fourths of it not exceeding 150 feet in altitude, but in the centre, between Cape Traverse or Sable River and New London, ridges and hills rise from 400 to 500 feet above sea-level. The surface is undulating or rolling with a number of valleys extending more or less transversely or diagonally across the island, though several, especially on the higher grounds, have nearly an east-and-west course, corresponding to that of the anticlinals on the mainland. During the post-glacial subsidence, when Prince Edward Island stood from seventy-five to eighty feet below the present level, there were four or five islands instead of one. Great denudation of the soft rocks of the island formations has taken place, the hills being due rather to this cause than to orogenic movements. The denudation has, however, been largely pre-glacial. The higher portions of the island have suffered less than the slopes and coast districts, and are covered with a thick sheet of residuary material. Prince Edward Island.

The Magdalen Islands exhibit some curious topographic features, as might be expected from their non-glaciated condition. Each island Magdalen Islands.

seems to have one or more masses of eruptive rocks (dolerite or diabase, porphyritic and amygdaloidal traps, etc.) which stand up in conical hills and have disturbed or broken through the Lower Carboniferous sediments. The general direction of these hills or ridges, where any linear arrangement is apparent, is approximately north-east and south-west, corresponding with that of the crystalline ridges in Nova Scotia and New Brunswick.

Rivers and Lakes.

Rivers flowing into Northumberland Strait.

The most important rivers in that part of New Brunswick embraced in this report are the Southwest Miramichi, the Richibucto and the Petitcodiac. The Southwest Miramichi is one of the large rivers of the province, being one hundred and twenty-five miles in length above its confluence with the Northwest Miramichi River. Several of its tributaries are rivers of no mean size, such for example, as the Renous, Dungarvon, Cains, Taxus, etc. A curious feature of this river is the proximity of its chief catchment basin to the valley of the St. John River, robbing the latter, as it were, of a portion of its waters. The Southwest Miramichi, like all the large rivers of New Brunswick, existed in pre-glacial times, its valley having been so deeply eroded then as to enable it to affect the movement of the Pleistocene ice, especially in the latter part of the glacial period. Glacial striæ parallel to its course are found along its sides. The north-easterly trend of its lower part and of its principal affluents, the Renous, Dungarvon, Cains, etc., indicates that the watershed separating its waters from those of the St. John River, was higher, relatively to the adjacent district to the north, in pre-glacial and glacial times, than at present.

The rivers flowing into Northumberland Strait, between the Miramichi and Pictou, Nova Scotia, are unimportant. Their silted up estuaries denote that the coast region is in a partially submerged condition compared with what it was in the Pliocene or late Tertiary age, when the valleys, now buried in sediments, underwent their final touches of erosion.

Petitcodiac River.

Of the rivers flowing into the head of the Bay of Fundy, the Petitcodiac and the Maccan are the largest and most important, and exhibit some remarkable features deserving of more than a passing remark. The first-mentioned of these has a singularly curving course, and in the estuarine part shows unique physical peculiarities. The non-tidal part, or that between Petitcodiac and Boundary Creek stations, Intercolonial railway, to which the name "Petitcodiac

Photo by H. Marshman.

PLATE I.—THE BORE, PETITCODIAC RIVER, MONCTON, N.B.
As seen on the 22nd of August, 1892; height, 5 feet 4 inches.

River" properly applies, is only thirteen miles in length. Above Petitcodiac station it is called North River. The latter rises in the higher grounds of Lutz or Indian Mountain, eight miles and a half north of Moncton, and flows south-westward for twenty-two or twenty-three miles, *i.e.*, in a reverse direction to that of the Petitcodiac River, properly so called, till it joins the latter. The Petitcodiac has, however, several tributaries of considerable length besides North River, and a very peculiar drainage system. Pollett River, one of these tributaries, flows northward from a source 1,200 to 1,400 feet high in the plateau bordering the Bay of Fundy; and Coverdale is another affluent rising in the same region. It is not improbable that the two latter, Pollett and Coverdale rivers, were, in pre-glacial times, the chief head-waters of the Petitcodiac, and that North River, if it had a pre-glacial existence at all, flowed south-westwardly along the valley of the Anagance River into the Kennebeckasis without joining the Petitcodiac. This theory as to the original drainage-basin of the Petitcodiac River presupposes somewhat different relative levels of the region, that on the north of the river being probably higher, or that to the south rather lower, than at the present day; or a slight differential uplift of the divide between the Petitcodiac and Kennebeckasis waters in the Pleistocene would produce the same result. If, however, North River is post-glacial this supposition is unnecessary.

"The bore" of the Petitcodiac River.

But it is in the tidal or estuarine part of the Petitcodiac River that the most interesting features occur, and that the singular phenomenon, called "the bore" is seen. The estuary extends from Folly Point, at the entrance to Shepody Bay, north-westward to "The Bend" at Moncton, where it takes a sharp curve to the south-westward, thence continuing to Salisbury on the Intercolonial railway, its whole length being thirty-two or thirty-three miles. At "The Bend," where the river's course is somewhat narrow, the tidal wave or "bore" can be seen to best advantage. Here it may be observed rushing in as a foaming breaker (see Plate I.) five or six feet high, with a velocity of six or seven miles an hour. After it passes, the waters flow in like a river, slackening off, however, before the full height of flood-tide is reached. The difference between low and high tide at Moncton is, at spring tides, forty-five feet, at neap thirty-eight feet.

The ebb-tide sets out, at first, slowly, but after an hour or two rushes along like a mill-race, the water sinking rapidly until the bare muddy channel is exposed and finally the river becomes a small meandering stream in the bottom. This continues for two hours or more, when again the rushing waters of the "bore" are heard and soon sweep past at their usual velocity.

Maccan River, "bore" of.

In the Maccan River, which discharges into Cumberland Basin, a similar "bore" occurs though not as high as that of the Petitcodiac.

At spring tides these tidal phenomena are of course seen to full advantage. The winds have also at times the effect of producing a perceptible difference in the height. A south-west wind may prevent the recession of the tides to their lowest possible level, and of course the incoming wave which follows will not be so high.

Other noteworthy peculiarities of the tidal phenomena of the Bay of Fundy will be referred to later on.

Tantramar River.

The Tantramar, which is chiefly a tidal river, also exhibits certain phenomena of a remarkable kind along its course. The sediment composing the Bay of Fundy salt marshes is known to be a finely divided material, and is carried in by flood tides and deposited along estuaries and on overflowed marshes. This operation of nature is, perhaps, better exemplified along the river referred to than elsewhere, in proof of which it is noticeable that the marsh surfaces are higher immediately on both sides of the river than at some distance from it, and that the material there is oxidized. Certain portions of the salt marshes are now undergoing artificial reclamation from the blue coloured, mossy, "corky" marsh, by draining and by allowing the spring tides to overflow them and deposit this red oxidized sediment. A considerable acreage of excellent marsh land near Sackville has thus been brought into a condition to produce abundant crops of hay.

Hebert and Maccan rivers.

Hebert and Maccan rivers, both of which flow into Cumberland Basin, likewise exhibit some singular features in their drainage systems. These rivers rise in the northern slopes of the Cobequid Mountains, but the Maccan has branches joining it from the north and east as well, *i.e.*, from the high grounds of Springhill and Leicester, and has, therefore, a pretty large catchment basin. The catchment basin of River Hebert is, on the contrary, small, the main source of the river being in a valley or pass in the Cobequid Mountains, through which the Springhill and Parrsboro' railway runs. The origin of this pass is one of the difficult problems appertaining to the surface geology of the region. It does not seem to be due to a fault or dislocation, but mainly to erosion. It is certainly pre-glacial but post-Carboniferous. Connected with this pass are two valleys, one through which River Hebert flows, the other extending from Halfway Lake to Southampton, thence along Maccan River to Athol and Maccan stations, Intercolonial railway. These valleys afford evidence of having been occupied by the sea during the post-glacial subsidence of the land, gravel- and sand-terraces and water-worn deposits being abundant in

them. A remarkable gravel ridge called the "Boar's Back," which will be described in the sequel, stretches along the valley of River Hebert.

Pre-glacial outlet of Maccan and Hebert rivers.

Viewing the drainage-basin of Maccan and Hebert rivers as a whole, especially in its relation to the pass in the Cobequid Mountains through which the Springhill and Parrsboro' railway runs, it appears to be not improbable that in pre-glacial ages the waters of these rivers found outlet southward through the pass referred to into the Basin of Minas, and may have been the agent of erosion to which it owes its origin. This erosion must date from a very early geological period, having commenced when the relative levels of the country were different, and previous to the elevation of the Cobequids, subsequent erosion and uplift going on concurrently until the advent of the ice age. The pass is now largely drift-filled, especially in the central part, the drift material there being due to glacial and post-glacial deposition. The differential uplift of the Cobequid Range since that date relatively to the Carboniferous area lying to the north, has caused this drainage to become partially reversed and to seek escape by the existing channels. This question will be discussed in further detail on a following page.

None of the rivers of Cumberland county flowing into Northumberland Strait exhibit any noteworthy features, except, perhaps, Wallace River, which affords proofs of once having been the outlet of Folly Lake. A slight rise of that lake would still allow it to overflow in the direction of this river. The change in the drainage here has doubtless been caused by the same orogenic uplift of the Cobequid Mountains that caused the northward flow of the Maccan and Hebert rivers, viz., the late upheaval or upheavals of that range relatively to the country to the north.

Lakes.

Lakes.

The lakes of the region are small and but few of them seemed to require special investigation. Several of the lakes on sheet No. 2 S.E. are bordered by mounds or gravel ridges produced by the shove of the ice which covers their surfaces every winter. One of these at the head of the south branch of Muzroll's Brook, a branch of Cain's River, has a kame on one side, and another small lake about the head of the millstream along the Kent Northern railway, called Lake Elsie, has a gravel ridge around its border. In early post-glacial times small shallow lakes must have been numerous in the Carboniferous area, but most of them have since been filled with peat.

Lakes on Isthmus of Chignecto.

On the Isthmus of Chignecto, there are a number of small shallow lakes, around the borders of the salt marshes of the Bay of Fundy. They have been formed by the stoppage of the drainage which flows down from the slopes upon the inner border of these marshes. A fringe of shrubbery grows around them on the surface of the marsh. Peaty material likewise accumulates in these places. Portions of these marshes are now being reclaimed and brought under cultivation by flooding them with the tidal water.

Lakes of the Cobequid Mountains.

The most remarkable lakes of the region are those of the Cobequid Mountains, including Halfway Lake lying at their northern base. This lake is merely the remnant of a much larger one which existed here in post-glacial times. Folly Lake affords evidence on the slopes of the hills surrounding it, that it stood at one time in post-glacial history forty feet above its present level, and overflowed into Wallace River, the gorge in the Cobequids here, to the north of Folly Lake, having in this way been eroded. A rise of from fifteen to twenty feet in the level of the lake would still enable it to flow in this direction. Mounds and ridges of gravel and sand, the material being well rounded, occur at both ends of the lake. There is no evidence of glacial action in the basin of Folly Lake, or in the gorge to the north of it; but a few small water-worn pieces of Carboniferous sandstone were observed among the local boulders.

Folly Lake.

Origin of Folly Lake basin.

The origin of the depression in which Folly Lake lies has not been determined. That the gorge or pass has been eroded by the action of running water there seems no doubt. But originally there must have been a catchment basin here in which to store up this water-power, and the question is, how was this formed? The only solution of the problem seems to be that it was orogenic, the existing topography, indeed, supporting this view. A circle of hills surrounds the depression forming the lake basin, and it is probable that previous to the formation of the gorges extending northward and southward from Folly Lake, it held in the larger body of water, the old shore-lines of which were observed at a height of forty feet above the present lake-surface. That this high-level, ancient, post-glacial lake is rock-rimmed seems pretty certain.

Several of the small lakes on the summit of the Cobequids contain infusorial earth which will be referred to on a subsequent page.

Bay of Fundy.

Bay of Fundy; origin of the name.

The name of this bay is said to have been given to it by the early Portuguese explorers. It was called by them Baya Fonda or Funda, or

Deep Bay, "expressing not the depth of its waters, but the depth to which it penetrated the continent." * During the French occupation of the country it was called "La Baie Française, or La Grande Baie de la Française," but this like other French names of places in this region was, when the French gave up possession of the country, replaced by what appears to have been the original name anglicized.

Some of the physical features of this remarkable bay were briefly described in a previous report. †

Its phenomenal tides, which are best exhibited in the eastern and north-eastern extremities, rise from fifty to fifty-five feet above low-tide level. The entire length of the Bay of Fundy to its inner extremities, supposing its mouth to be at Grand Manan Island, is about one hundred and forty-five miles, its width at the mouth forty-eight miles; between Digby Gut and the mouth of the St. John River, forty miles, and from the entrance to Minas Basin to Salisbury Bay, thirty-five miles. The bottom of the bay has a gradual ascent from the mouth to the north-east extremities, the depth below mean tide level at the former place ranging from seventy to one hundred and ten fathoms. Taking an average gradient of the bottom of the bay from its mouth to the head of Shepody Bay, we find that it is not less than four feet per mile. Of course it has many inequalities, and rises abruptly towards the shore in some places, but on the whole is remarkably uniform for a bay the waters of which are affected by such powerful currents. Tides of.

In reference to the tides of the Bay of Fundy, it can be seen from an examination of the charts of the British Admiralty Survey, and of the United States Coast Survey, that immediately outside of the mouth of the bay they rise higher than in the open ocean, the sea apparently being heaped up against the coast of the mainland. For example, south of Pubnico harbour, Nova Scotia, and just east of Seal Island, the spring tides rise twelve feet and three-quarters, and neap tides ten feet and a quarter, while near the coast of Maine and west of Machias Seal Island, spring tides rise eighteen feet, and neap, fourteen feet and three quarters. Rise and fall of the tides of the Bay of Fundy.

* The Portuguese on the North-east coast of America, and the first European attempt at colonization there. By the Rev. George Patterson, D.D. Trans. Royal Society of Canada, 1890, vol. VIII. A history of the Discovery of Maine, U.S., by J. G. Kohl, vol. I., edited by Wm. Willis, Portland, Me., Bailey and Noyes, 1869.

† Annual Report, Geol. Surv. Can., vol. IV,. N.S., 1888-89, p. 16N.

Inside of the mouth of the Bay of Fundy, however, the rise in the tides increases more perceptibly as we advance from the mouth towards the north-east extremity, as shown by the following table :—

Places.	Spring Tides.	Neap Tides.
	Feet.	Feet.
Digby Neck, N.S	22	18
L'Etang Harbour, N.B	23½	20
Point Lepreau	24½	21
Digby Gut, N.S	27½	23
St. John, N.B	27	23
Quaco, N.B	30	25
Spicer Cove, N.S	37	30½
Advocate, N.S	39	33
Cape Enragé, N.B	41	32
Petitcodiac River, N.B	46	36
Apple River, N.S	39	29
Cumberland Basin	44	35
At west dock, Chignecto marine railway	44	35
Noel River, in Cobequid Bay	53	31

This last is the greatest tidal oscillation in any part of the Bay of Fundy.

Explanation of their rise and fall.

The greater rise of the tides in the upper parts of this bay is attributed to its narrowing funnel form, and its shallowing bottom cooping up the tidal wave as it advances up the bay. But it would seem that the waters really acquire a movement of translation as they enter the narrow bays and inlets and become as it were heaped up, the upper parts rolling over the lower in the way that waves break upon the shore. The "bores" exemplify this. The ebb tides are not so easily understood. That the inward rush of the tidal wave should raise the waters from twenty to twenty-five feet above the mean level of the ocean in these narrow bays with ascending bottoms can be readily explained, but why these waters should recede to a depth of twenty feet or more below the same datum, leaving the bays empty, or nearly so, for hours, is a phenomenon, the cause of which is not so apparent. That it is the result of gravitation—of an effort of the waters to reach an equilibrium—is unquestionable. The bottom of the Bay of Fundy, as already shown, is really in the form of an inclined plane, the average slope being, as stated, about four feet per mile, while the average slope of the surface of its waters at flood tides within the bay is one hundred and fourteen thousandths (·114) feet per mile ; in other words, the waters are then sixteen feet higher, in round numbers, at the inner extremities of the bay than they are at the mouth. At every flood tide therefore, there is a great body of water in the upper end of the bay, carried to a position above the normal level of the ocean. Gravi-

tation seeks to restore an equilibrium. The receding waters of the ebb tides, descending an inclined plane, as it were, rush down with such force and rapidity that, like the receding waves on a shore, they fall below the mean level of the sea about as far as they had risen above it at the flood. Then follows another abnormal condition of things; the surface of the waters of the bay again loses its horizontality, but this time the slope is in the reverse direction to that of the flood tide, viz., from the inner or eastern extremities of the bay outwards and upwards towards the mouth. Another effort is therefore made to restore the equilibrium, and the great tidal wave rushes in once more. This oscillating or rythmic flow and ebb of the Bay of Fundy waters thus goes on throughout the ages, and not until the contours of the bay are changed from erosion or subsidence, and the tidal wave is allowed to pass over the Isthmus of Chignecto into Northumberland Strait, will it cease.

It has been assumed that the slopes of the surface of the Bay of Fundy at flood and ebb tides were regular or comparatively so; but the conformation of the sides and bottom seriously affects, and in some places, obstructs the tidal flow. The slopes are, therefore, only approximately regular.

Mean tide level in Bay of Fundy and Northumberland Strait.

It may be asked how do we know that the ebb tide falls as far below the mean tide level of the ocean, or mean sea-level, in the bays and inlets of the Bay of Fundy as the flood tide rises above it? In answer to this we will state that it has been ascertained by careful levellings above a common datum in the surveys of the Baie Verte canal and of the Chignecto Marine Transport railway that mean tide-level, *i.e.*, the level of half tides, closely corresponds on both sides of the Isthmus of Chignecto. For example, the levels of the Chignecto marine railway have their datum one hundred feet below the high-water mark of the Saxby tide, a remarkable tide which occurred on the 5th of October, 1869. From this datum, the heights of the tides at both ends of the marine railway, viz., at the Tidnish dock and at the Fort Lawrence dock, have been measured, during at least one whole season, with the following results:—

Datum of Chignecto marine railway.

At Tidnish dock, Baie Verte—

	Feet.
High water, spring tide	79·
" ordinary tides	74·
Low water	68·40

At Fort Lawrence dock, Cumberland Basin—

	Feet.
High water, spring tides	96·
" ordinary tides	89·
Low water	52·59

Correspondence of mean tide level at both ends of the Chignecto marine railway.

The levellings were started from the Tidnish dock. H. G. C. Ketchum, C.E., of the Chignecto marine railway states that "the extreme range of the tides in Baie Verte was observed to be 10 feet 8 inches; the ordinary range being only 5 feet 7 inches. Thus while the fluctuations above and below the mean sea-level were only 2 feet 9 inches at Baie Verte, they were at the same time 19 feet above and below mean sea-level in the Bay of Fundy at neap tides and 24 feet at spring tides."*

From the data at hand it has been shown, however, that the level of half tides, usually called mean sea-level, does not strictly correspond on both sides of the Isthmus of Chignecto, there being a difference of a few inches (5 to 10 inches). But this difference is so small that it may well be due to slight errors in the observations or in the levellings.†

The statement that the tides of the Bay of Fundy rise from forty to sixty feet high, signifies that they rise that number of feet above low-water mark. Their rise above the normal mean tide-level of the ocean is approximately only half of these figures. As a matter of fact, the highest tidal flow in any part of the Bay of Fundy, which, as already shown, is at Noel Head, in Cobequid Bay, is only fifty-three feet above low-water mark, according to the Admiralty survey.

Tides of the Bay of Fundy in the Pleistocene

In studying the tides of the Bay of Fundy the question arises, what was their maximum rise and fall during the Pleistocene period, more especially during that stage when the Isthmus of Chignecto was submerged and Nova Scotia formed an island? From the levels taken in the surveys of the Baie Verte canal and of the Chignecto marine railway, it appears the axis of the isthmus in its lowest part is not at present more than eighteen or twenty feet above the high tide level of Cumberland Basin, in the Bay of Fundy. No drift-filled channel crossing the isthmus has been found; on the contrary, the rock *in situ* appears, even in the lowest places, to be covered with boulder-clay, residuary material, etc., and has evidently not suffered greater erosion on the lower levels, in post-glacial times, than other parts of the country. But there is evidence which will be adduced in this report showing that in the Leda-clay and Saxicava-sand period the isthmus was submerged to the depth of at least one hundred and twenty feet. How would the Bay of Fundy tides act during this subsidence? An inquiry into their height and dynamic power in the wider parts of the bay, as it exists at the present day, will, perhaps,

*The Chignecto Ship railway, a paper read before the Canadian Society of Engineers at Montreal, Dec. 29th, 1891, by H. G. C. Ketchum, M. Inst. C. E.

†The Tides of the Bay of Fundy. By M. Murphy, Provincial Engineer, N.S. Proc. Inst. of Nat. Science, Halifax, Nova Scotia, vol. VII., page 48.

be our best guide in elucidating this question, those parts of the bay being no wider or deeper than the strait across what is now the Isthmus of Chignecto would be at the time of the subsidence referred to. Would the tides during the post-glacial submergence of the isthmus be as high in the north-east extremities of Chignecto Bay as at present?

Effect of changes of level upon the tides

The remarkable tidal phenomena of the Bay of Fundy being due to the convergence of its sides and the shoaling of its water towards the north-east, it follows that if the barrier there were removed and the tidal wave allowed to flow without obstruction into Northumberland Strait, the conditions favourable for high tides would be diminished if not entirely eliminated. The tidal wave which now moves up the bay with such velocity (six to seven miles an hour in some places) instead of being stopped and thrown back, would then sweep across the isthmus into the open sea beyond. It is not probable, therefore, that the tides would rise any higher than they do now in the mouth of the bay or in the Gulf of Maine; indeed, all things considered, there seems no reason to suppose that the highest tides during the maximum stage of the submergence referred to would exceed from ten to fifteen feet.

Erosion from Bay of Fundy tides.

But although the tides during this stage of the Pleistocene submergence were not as high as at present, their dynamic effect in the erosion of the shallow parts of the strait and coast border, which then existed on both sides of what now forms the Isthmus of Chignecto, was very great. It was then that the low-lying portions of the isthmus received their present contours, that the Kennebeckasis Valley in New Brunswick and the Annapolis Valley in Nova Scotia were eroded, if not wholly, yet received their latest sculpturing, and that the precipitous sides of the lower Petitcodiac Valley, the Memramcook Valley and Cumberland Basin, etc., were carved out and fashioned nearly as we now see them. It must be remembered, however, that all the valleys, now partially filled or occupied with salt marsh, would then be comparatively empty, and denuding agents would have much greater scope.

The chief erosion of the isthmus from marine action appears to have been during the upward movement of the land in the later stage of Leda-clay and Saxicava-sand period. In the earlier stage of the Pleistocene subsidence the isthmus would, of course, be covered wholly or partially by ice, either land, or floating ice, or both, and consequently erosion from the sea would then be less active. Tidal erosion must therefore have been active chiefly after the retirement of the ice and before the tidal wave was shut off from Northumberland

Strait and confined to the Bay of Fundy, by the elevation of the axis of the isthmus above sea-level.

Action in depositing sediments.

As soon as the rising of the land in the Leda clay and Saxicava-sand period had brought the present geographical barrier between the Bay of Fundy and Northumberland Strait into existence, the tidal wave, thrown back on itself, would begin to deposit its burden of sand, mud, etc., in the estuaries and bays. This process has been in active operation since, and it is in this way that the sediments of the extensive salt marshes have accumulated. The action of the tidal wave in the north-eastern extremities of the Bay of Fundy is therefore accumulative and not destructive, that is, it deposits material where it is thrown back on itself, but further down the bay, where it receives no check to its onward progress, its erosive power, especially on the shores, is very great.

Flow and ebb in later Pleistocene.

During the maximum subsidence of the land in the Pleistocene period the tidal wave or current may have passed over the submerged Isthmus of Chignecto in both directions,—at the flood running north-eastwardly through what then formed a strait between New Brunswick and Nova Scotia, and at the ebb in the reverse direction from Northumberland Strait or the Gulf of St. Lawrence, into what is now the Bay of Fundy and Atlantic Ocean. Erosion would then, no doubt, be powerful, but not as powerful as at the present day, as the tidal oscillations would be similar to what they are now in the open and wider parts of the bay.

It was probably during the early stage of the subsidence mentioned that the isthmus received its final glaciation from the floating-ice jammed in between Prince Edward Island on the one hand, and on the other, the higher grounds of New Brunswick and Nova Scotia on both sides of the isthmus. This ice moved chiefly from Northumberland Strait south-westward into the open waters of the sea now forming the Bay of Fundy, but also partially in the reverse direction. The evidence bearing on this question will be brought forward on a later page.

Origin of the Bay of Fundy depression.

The origin of the great depression in which the Bay of Fundy lies is a question the adequate discussion of which would lead us far back in geological history. Prof. H. Y. Hind speaks of it as a valley of erosion,* and this is doubtless partially correct; but originally it must have been formed by crustal movements, though at what geological period is not evident. The Carboniferous rocks bordering Northumberland Strait are but slightly disturbed, but when we cross the Isth-

*A Preliminary Report on the Geology of New Brunswick, 1865.

mus of Chignecto to the head of the Bay of Fundy a marked difference in their position and in the structure of the beds is found. The Lower Carboniferous there is generally folded and thrown into highly tilted attitudes, while the Middle Carboniferous (Millstone grit), though in many places occupying a horizontal attitude has, on the west side of the Petitcodiac River, in Cape Maringouin peninsula, at Westmoreland ridge, and at South Joggins and Springhill likewise suffered great dislocation and faulting. The promontories, projecting into Chignecto Bay and even Cape Chignecto itself appear to have also undergone differential uplift relative to the coast border of Northumberland Strait, and doubtless were affected by the same orogenic influences as the Cobequid Mountains themselves. The sequence of these movements seems to have been, an upheaval after the Lower Carboniferous rocks were formed and previous to the deposition of the Middle Carboniferous beds; then another disturbance and fracturing of the strata subsequent to the formation of the coal series. Since Carboniferous times the region appears to have undergone repeated oscillations, the latest being the subsidence in the recent period. This question will, however, be referred to in detail, when I come to treat of the changes of level which took place here in the Tertiary and Post-Tertiary periods.

The crustal oscillations to which the Bay of Fundy valley is due seem, therefore, to have been to a large extent local, at least they were much more intense immediately around it than in the region of Northumberland Strait. Evidently the origin of this depression has been dependent upon and closely related to the crystalline ranges on both sides of the bay, the proximity of which doubtless led to so much local disturbance of the Carboniferous and other rocks, as referred to. Upheaval and denudation have been proceeding in some instances correlatively and *pari passu*, and have brought about important changes in the surface features. The excavation of the valleys now occupied by the estuaries of the Petitcodiac, Memramcook, Tantramar and La Planche rivers, which have in Post-Tertiary times been partially filled with boulder-clay, salt marsh deposits, etc., indicates intense and prolonged erosion.

Due probably to crustal movements.

The physical features and dynamic action of this remarkable bay have been thus dwelt upon, because it occupies a valley where intense forces have been and are still in operation, and where the formation of salt marshes in the Recent Period is exhibited on a scale unparalleled elsewhere in Canada. Nor have we on any other part of the North American coast evidence of such a trustworthy character respecting the subsidence of the coast in the latest epoch of its geological history.

TERTIARY AND POST-TERTIARY CHANGES OF LEVEL.

Changes of level in later Tertiary and Post-Tertiary.

Considerable attention has been devoted of late years to the changes of level of the earth's crust, especially in the Post-Tertiary period. That great oscillations have occurred is undeniable, but the evidence as to the extent of the vertical movements is, for the most part, extremely fragmentary, and no very satisfactory conclusions have been deduced from it. Nevertheless, along the coasts a large body of facts awaits investigation and co-ordination, which would elucidate this question. Shore-lines, marine terraces and benches of different kinds lie exposed in every estuary and along every coast, the heights of which, if properly measured and classified, would form an important contribution to our knowledge as regards these oscillatory movements. The amount of deformation by differential upheavals and subsidences could also by this means be shown, and the efficiency of certain theories to account for the phenomena properly tested.

Data, where obtainable.

Where collected.

For a number of years the writer has been collecting all the information available respecting the oscillations of level on the Atlantic coast of Canada, especially in the region lying between the mouth of St. Lawrence River and the International boundary. The following table embodies the results of this investigation :

Table of elevations and subsidences.

No.	Localities.	Elevation in later Tertiary above mean tide-level, in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	EASTERN QUEBEC.			
1	Along Temiscouata Ry., near Rivière du Loup station, I.C.R.	Not known, but 840 or upwards in mouth of Saguenay River opposite Rivière du Loup.......	418 (bar.)........	Not known.
2	Between Rivière du Loup and Ste. Flavie..........	" ..	345 to 375 (bar.).	"
3	Gaspé Basin..............	This basin 180 ft. deep between Capes Brulé and Haldimand....	225 to 230 "	"
4	Port Daniel, on north side of mouth of Baie des Chaleurs....................	Not known......	225 to 250 "	"
5	Between Carleton and Maria in Baie des Chaleurs.....	"	200+ "	"
6	West of Nouvelle River and between that and Scaumenac..................	"	215 to 220 "	"

No.	Localities.	Elevation in later Tertiary above mean tide-level, in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	NEW BRUNSWICK.			
7	Near Dalhousie Junction, I.C.R., on south side of Restigouche River.......	73 at least, at mouth of Metapedia River; 90 at mouth of Restigouche River.	223 at end of trap ridge; probably higher than normal (spirit level)	5 at least, according to peat bed at Charlo.
8	Near Bathurst, on road to Dunlop settlement......	Not known......	188 " ..	5 to 10.
9	Near Caraquette, south of harbour.......	40 to 50 or more.	138 (bar.).......	5 to 10 between St. Simon Inlet and Pokemouche, also on Miscou Island.
10	North side of Miramichi River, between Newcastle and Bartibogue River....	115 at least	125 to 135 (bar.).	10 to 15.
11	On Cape Tormentine peninsula, along Emigrant Road	See page 27 M...	125 (?) (bar.)	Not known.
12	Near Berry's Mills station, I.C.R.	Not known......	251·95 (sp. level).	"
13	Indian Mountain, north of Moncton................	See page 27 M...	248·91 " ..	"
14	In another place further east, along south base of Indian or Lutz Mountain	" " ..	251·95 " ..	"
15	At Hillsboro', Albert county	" " ..	222·44 " ..	15·32 (sp. level).
16	At St. John, east of harbour	200+...........	225·91 " ..	10 to 15.
17	At Pennfield station, Shore Line Ry., on Pennfield terrace..................	Not known......	228 (Ry. levels)..	Not known.
18	Five miles east of St. George on highest part of Pennfield terrace.............	90, or more at mouth of L'Etang Inlet......	243 " ..	"
19	On marine terrace, at Dyer's crossing, in valley of Digdeguash River..	Not known......	231 " ..	"
	NOVA SCOTIA.			
20	Half a mile north of Nappan station, I.C.R...........	See page 27 M...	143·72 (sp. level).	10·75 at Fort Lawrence; 79 at Aulac.
21	On north side of Amherst Head....................	" " ..	138 to 140 (bar.).	Not known.
22	On east side of Mount Pleasant, in River Philip valley	Not known.....	133 (bar.).......	"
23	Between Wallace harbour and Pugwash............	"	133 "	"

No.	Localities.	Elevation in later Tertiary above mean tide-level, in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	NOVA SCOTIA—*Continued.*			
24	On peninsula north of Wallace Harbour, in several places, distinct.	Not known.....	133 (bar.) Other shore lines at 120, 110, and 55 to 60......	Not known.
25	East of Wallace, on road running south from Plaster Cove.............. .	"	138 (bar.).......	"
26	On Wallace Ridge, east of road going south from Plaster Cove, in several places..................	"	133 "	"
27	In Deware River Valley.	"	138 "	"
28	South-west of Athol Station, I.C.R..................	"	138 "	"
29	On north side of Claremont Hill..................	"	135 to 140 (bar.).	"
30	At Thomson Station, I.C.R.	"	138 (bar)........	"
31	On east side of Halfway River, at northern base of Cobequid Mountains....	See page 28 M...	170·84 (sp. level)	"
32	Halfway between the last and Lakelands, a bench on east side of pass..........	Not known.....	186 (bar.)......	"
33	At Lakelands, on both sides of valley or pass..........	"	223 "	"
34	Further south, at head of Parrsboro' River, on east side of valley or pass.....	"	160 " ...	"
35	Still further south, on east side of valley, at south base of Cobequids.	"	130 "	"
36	On south side of Cobequids and west of Parrsboro'—a wide terrace.............	"	110 to 115 (bar.)..	"
37	At Port Greville............	"	112 (bar.)........	"
38	At Spencer's Island........	"	128 "	"
39	At Advocate Harbour.....	"	130+ "	"
40	Near Granville, at foot of North Mountain (terraces)	"	110 "	"
41	At mouth of L. Quille Brook, south of Annapolis	"	110 to 115 (bar.).	"
42	Near head of St. Mary's Bay, at base of North Mountain....................	"	110 (bar.).... ...	"
	PRINCE EDWARD ISLAND.			
43	West of Alberton..........	"	75 "	5 to 10.
44	At west end of O'Leary Road, near Cape Wolf...	"	75+ "	Not known.
45	At Coleman Station, P. E. Island R..	"	75 "	"
46	At Ellerslie Station, P. E. Island R............. ...	"	75 "	5 to 10.

No.	Localities.	Elevation in later Tertiary above mean tide-level in feet.	Elevation of highest Pleistocene or post-glacial shore line above mean tide-level, in feet.	Subsidence in the Recent Period below mean tide-level, in feet.
	PRINCE ED. ISLAND—*Con.*			
47	North of Kensington, near P. E. Island R.	Not known......	75 (bar)..	Not known.
48	At Wilmott's Creek, near P. E. Island R.	"	75 "	"
49	At Tryon River...........	"	75 to 95 (bar.)...	"
50	At North River Bridge, P. E. Island R...... ...	"	75 (bar.)........	"
51	In Oswell Bay............	"	75 to 80 (bar.)...	"
52	At Souris............. ...	"	75 (bar.)........	"
	MAGDALEN ISLANDS.			
53	On Amherst, Entry, Grindstone and Alright Islands.	"	110 to 115 (bar.).	"

Tertiary elevation of the coast border.

The data respecting the height of the region in the later Tertiary are necessarily imperfect, and only at the mouths of the Restigouche, Miramichi and St. John rivers have we measurements which may be relied upon as correct. They are minimum figures, however, and the elevation must have been considerably greater than that they represent. At the two first-mentioned rivers, borings were made for foundations to the Intercolonial railway bridges spanning them, through gravel, sand and clay to the depths below tide-level here given, showing that at a period anterior to the Post-Tertiary the land stood at such an elevation as permitted the rivers to flow along their rocky floors and erode them to that level. That this erosion continued to the later Tertiary, is inferred from the fact that no deposits of that age have yet been discovered in the bottoms of these river-valleys. At St. John, the figures are taken from the Admiralty Survey charts, the depths being those of the St. John River above Indiantown and of the Kennebeckasis near its confluence with the latter. To enable the two last-mentioned rivers to erode the valleys in their lower reaches down to the rocky floor, the land must have stood two hundred feet or more above its present level. It is probable, however, as stated above, that the heights for the Tertiary border of the land in the northern and southern parts of New Brunswick do not represent the maximum elevation. There are reasons for believing that some parts at least were much higher. For, the mouths of the rivers referred to, must be largely silted up ; and, moreover, the buried channels where the borings were

made are so far up the river-valleys that they may have been beyond the then existing estuaries.

On the whole, the evidence thus far obtained points to a difference in elevation in the later Tertiary period of certainly not less than from two hundred to three hundred feet above existing levels. The difference was not, however, equal throughout the whole coast region from the mouth of the St. Lawrence to the St. Croix River or International boundary. Certain facts now to be adduced show, on the contrary, that the Tertiary oscillations, like those of other geological periods, before and since, have been differential, and the upheavals and subsidences to some extent, at least, complementary. The facts upon which this conclusion is based were observed chiefly in the Isthmus of Chignecto and in the region around the head of Chignecto Bay. It seems necessary to give them in some detail.

Evidence as to changes of level at the head of the Bay of Fundy.

The district around the head of the Bay of Fundy is remarkable for the great changes of level which have taken place there throughout its geological history. The evidences of these are first recorded in the Carboniferous rocks as exhibited in the celebrated South Joggins section described by Logan and Dawson.* At the close of the Carboniferous period, the land here rose and appears to have continued above sea-level until the glacial epoch, no rocks of the intervening geological periods having been met with on the Isthmus of Chignecto or around the head of Shepody Bay and Cumberland Basin. On the contrary, the rock-surface of the country seems during these ages to have undergone a great amount of subaerial denudation, as evidenced by the quantities of residuary material still found upon it. During the geological interval referred to, there appears to have been a ridging up of the Isthmus of Chignecto, which continued till after the beginning of the Pleistocence, and till the surface of the region became covered with a sheet of ice. Striæ are found on hills and ridges, from five hundred to six hundred feet high or more near Shepody Mountain in Albert county; at Dorchester Cape, three hundred feet high; at Westcock, there hundred feet high, and along the Cumberland shore to the south of South Joggins as far as Apple River, three hundred and eighty feet high, all trending from south to south-west with the stoss side clearly to the north-east, showing the movement of a heavy mass of land ice in the direction indicated. On the north-east side of the isthmus, along Northumberland Strait, the land is low, seldom rising more than from one hundred to one hundred and fifty feet in height, the greater portion not exceeding from sixty-five to seventy-five feet. Where, then, had the glacier which produced the striæ just referred to its

Height of Isthmus of Chignecto at present.

*Acadian Geology, 2nd ed., p. 133. Supplementary Note to 4th ed., p. 18.

source or collecting ground? Careful and repeated examinations of the coast district of Northumberland Strait and of the higher grounds of Prince Edward Island to the north-east showed, that no ice capable of producing these striæ came from that quarter, rather we have the evidence of land ice moving in an easterly direction in the strait and on Prince Edward Island at the time the Chignecto glacier was in existence. The striæ referred to have clearly been produced by land ice during the early stage of the glacial period, the action of floating ice within the same region evidently belonging to a later stage of the Pleistocene. How then were these striæ produced, or rather what caused the ice producing them to move from what is now a lower district south-westward over ridges and along slopes from five hundred to seven hundred feet in altitude? Only one answer can, in my judgment, be given to this question, viz., that the axis of the Isthmus of Chignecto and the valley occupied by the waters of Northumberland Strait as far to the north-east as Prince Edward Island, were higher relatively to the basins occupied by Shepody Bay and Cumberland Basin than at present. This differential elevation, existing in the Tertiary, continued into the early Pleistocene, as will be shown on a subsequent page. This explanation does not imply that the axis of the isthmus was elevated five hundred or six hundred feet above the present bed of Chignecto Bay, but that the difference in the relative levels amounted to that. The land to the north-east must have been higher, while that to the south-west was lower; the attitude of the district being such that the general slope was south-westward, to enable the ice to flow in that direction. On no other hypothesis can the facts be explained.

Height of Isthmus of Chignecto in the Tertiary period.

If this conclusion be correct, the height of the Isthmus of Chignecto during the Tertiary period was, therefore, different from that which now obtains, and further, the bottom of the depression now occupied by Chignecto Bay and the smaller bays and estuaries connected therewith must have oscillated very considerably since. We may now inquire whether there are any data showing that other portions of the region under review occupied different relative levels during the Tertiary period.

Pass in the Cobequid Mountains at Halfway River.

On page 12 M reference is made to the existence of a pass in Cobequid Mountains at Halfway Lake, through which the Springhill and Parrsboro' railway runs. This pass is about six hundred feet deep below the summit of the mountains, and quite narrow, with steep sides, and the drift-encumbered bottom is, in the central or highest part, now only eighty-five feet above mean tide-level. The character of the rocks on either side is the same, there being no evidence that the pass was due

to an original transverse fracture or dislocation of the mountain range. It is simply a valley of erosion, which can scarcely be explained by marine currents. No Carboniferous rocks are found in it. How then was it eroded? Evidently by the slow, long-continued agency of running water. Two small streams head near the centre of the pass, their sources being in two small lakes only a short distance apart and separated by a gravel bank. Halfway River, one of these (the lower part of which is called River Hebert), flows northward in a low valley, with bordering slopes two hundred to three hundred feet above sea-level, and empties into the north-eastern end of Cumberland Basin. The other, called Parrsboro' River, flows southward into the Basin of Minas. But these rivers are evidently insufficient to erode the pass. It cannot have been formed otherwise than by a river flowing through in one direction or the other. In which direction did this river flow and where was its catchment basin? From the physiographic features of the region, it is obvious that only on the north side of the mountains could there have been such a catchment basin, viz., in the district drained by the Maccan River; and it seems highly probable, therefore, that in pre-glacial ages this river flowed southward through the pass just described. Its upper branches, indeed, trend in this direction still, and between Southampton and Halfway Lake there is a low valley, now unoccupied by any stream, which doubtless was the ancient valley of the Maccan River when it had a southward course, but was abandoned when the river became diverted northward. But were the waters of the Maccan River alone sufficient to erode the pass in the Cobequids? This seems doubtful, unless the precipitation was much greater than at present. But it is not only the Maccan which may have flowed southward, River Hebert, or rather a river then flowing along its valley may also have had a reverse course with a catchment basin in the depression in which River Hebert and Maccan River now unite. To render this possible two postulates have to be assumed; first, that the land to the north of the Cobequids was higher and the Cobequids lower, that is, the mountains were then in their incipient stage,—in short, that the watershed of the area lying west of River Philip and Economy was not the Cobequid Range as at present, but extended across by Springhill and Maccan Mountain, and along the axis of the Isthmus of Chignecto westward, and, secondly, that the basin in which the Maccan and Hebert Rivers meet was closed to the west. It may have been that even the La Planche and Missaquash Rivers also drained into it. Be this as it may, it seems to have been in this way that the erosion of the pass through the Cobequid Mountains

How formed.

was effected. This erosion must, however, have commenced long before the Tertiary period and have kept pace with the uplift of the mountain range as it proceeded.

Period when the erosion of the Cobequid Pass referred to took place.

The theory outlined regarding the origin of the Cobequid Pass, takes us back to the incipient stage of the history of the western part of the Cobequid Mountains. At what geological period did they first rise above the surrounding strata? No rocks older than the Carboniferous are exposed in this district to the north of these mountains; and the rivers which are supposed to have been instrumental in eroding the pass have their courses superimposed on these strata. It is therefore a reasonable inference that erosion of the pass did not commence until after the Middle and, perhaps, the Upper Carboniferous rocks were laid down. Other facts lend support to this theory. For example, sandstone and conglomerate boulders belonging to Carboniferous rocks are sparingly scattered on the northern brow and summits of the Cobequids. The presence of these in the position referred to is attributed to the overlapping or transgression of these Carboniferous rocks upon the Cobequid series in past ages, there being no system of glaciation known to me which could have transported them thither with existing levels. Since then the denudation subsequent to the Cobequid uplift has removed the greater part of the sandstones and conglomerates from the summit of the mountains, leaving isolated patches and boulders merely as remnants.

Its erosion coincident with the rising of the Cobequids.

The work of eroding the Cobequid Pass referred to, seems to have gone on *pari passu* with the uplift of the range and continued as late as the Tertiary and early Pleistocene, the river keeping it at base-level; but during the glacial period it received a check and the movement of upheaval gained the ascendency on the erosive forces as shown by the fact that the pass, especially in the central part, is now occupied by heavy beds of drift. On the retirement of the Pleistocene ice the present drainage systems seem to have been inaugurated. The upward movement in the western Cobequids did not, however, cease, but continued into the later Pleistocene and may, indeed, still be in progress.

The phenomena therefore when co-ordinated, indicate a higher level for the Carboniferous series along Northumberland Strait and the region north of the Cobequids during the later Tertiary, probably corresponding to the level of that of the Miramichi basin in the same period. This altitude of the coast border was maintained until after the advent of the ice age.

Date of upheaval of Cobequids.

Reference has already been made to the initial stage of the local upheaval which resulted in the formation of the Cobequids. The up-

heaval seems to have commenced after the deposition of the coal measures, as the Upper Carboniferous rocks in some places contain débris derived from the crystalline rocks of the Cobequid series; but a general post-Carboniferous rise of the whole region also took place. That the Cobequid uplift has been going on since the glacial period is unquestionable, as post-glacial terraces and deltas, evidently of marine origin, found near Halfway River, in the northern part of the pass referred to, have a height above mean tide level of about 171 feet (see table) and near Lakelands, on both sides of the pass, of 223 feet; while well-marked shore-lines north of the mouth of Maccan River and along Northumberland Strait, occur at elevations of only 130 to 140 feet, showing a differential uplift of the Cobequid Range of, at least, eighty-three feet or more within post-glacial times.

Post-glacial invasion of the Cobequid Pass by the sea.

During the post-glacial subsidence of the region, the sea extended through the Cobequid Pass from the Basin of Minas along the valleys of Halfway River, River Hebert and Maccan River to the head of Cumberland Basin. At present the highest point, of what was then the bottom of a strait by the River Hebert valley and through the Cobequid Pass, lies in the central part of the Cobequids, and as stated above, is, eighty-five feet above mean tide level.

It may be remarked that the foregoing statement in reference to the initial uplift of the Cobequid Mountains is supposed to apply only to the western part; the eastern part may be, and doubtless is, older.

Relation between the changes of level in the Cobequids and in the Isthmus of Chignecto.

These differential changes of level in the Cobequid Mountains and in the region lying to the north, and indeed to the south of them as well, during the Tertiary and Post-Tertiary periods (see table) are, therefore, in harmony with those supposed to have taken place in the Isthmus of Chignecto during the same geological age.

Changes of level in the crystalline range of southern New Brunswick.

The crystalline range of southern New Brunswick, extending along the Bay of Fundy coast from Shepody Bay to the International boundary, exhibits some features which lead me to infer that, besides the general oscillations of Post-Tertiary date, a slow, secular, upward movement relative to the Carboniferous area to the north has also been in progress. The zigzag courses of the St. John River in the lower part of its course, the occurrence of waterfalls at the mouths of this and a large number of other rivers traversing this crystalline belt and emptying into the Bay of Fundy, and several facts respecting the glaciation of the region, lead to this inference; these being conditions which would not be likely to prevail had there been no displacement of the river, beds or differential movements.

Attitude of the Region, and Changes of Level in the Glacial Period.

Changes of level in the glacial period.

A number of facts have been obtained in the region under discussion which show the attitude of the coast border with respect to sea-level, approximately at least, during two stages of the glacial period. From the data at hand it appears that the greater elevation of the later Tertiary period continued into the Pleistocene, and, perhaps, was one cause of the ice accumulation. No evidence of a subsidence in the early stage of the ice age has been found in this region. The residuary material such as rotted rock, consisting of sand, gravel, boulders, etc., found in many places, evinces no action of water; and the hardened peat bed met with at River Inhabitants in Cape Breton by Sir J. W. Dawson* testifies to the fact that the land there must have been above the sea just previous to the deposition of the boulder-clay which overlies it.

Coast border probably higher in the early part of the glacial period.

In the earlier part of the glacial period, the ice in several places extended beyond the present coast border, and its movements were apparently affected by the peculiar local topographic features of the bays and estuaries. Striæ are met with in many localities running down beneath the sea, and as the facts prove that the ice (except perhaps, in southern New Brunswick, near the International boundary), cannot have been thick or heavy, it follows that the land must have been as high, if not higher than at present, in order that the valleys and estuaries could influence the ice movements in the manner supposed. If the coast border were lower, the ice moving outwards and discharging into these bays and depressions would have been broken up and floated off as icebergs, before it scored the rocks on the low levels to which it reached, and could not possibly have been guided in its movements by the conformation of these valleys as it appears to have been.

Evidence as to the altitude of the land, relative to sea-level, at this stage.

Commencing at Gaspé Basin, where there is evidence of a local glacier discharging from the valleys of the York and Dartmouth rivers into it, described on page 89 M, although no facts were observed indicating the exact height of the land here at this stage, yet from the position of the striæ on both sides of Gaspé Basin, and of the ice margin, it is inferred that the glacier was small, and that the land was as high as at present and probably higher.

At Baie des Chaleurs.

The western end of the Baie des Chaleurs depression was occupied by a glacier in the early Pleistocene, which seems to have extended as far eastward as Belledune Point and Bonaventure River. This

*Acadian Geology, 2nd ed. p. 68.

glacier followed the trend and sinuosities of the Restigouche estuary and the valley of the bay, and this fact leads me to infer that the land was rather higher than at present when the glacier reached its maximum thickness and extent, withdrawing to the slopes to the north, west and south coincidently with the subsidence which followed.

In Northumberland Strait.

The evidence respecting the attitude of the area covered by the Northumberland glacier, so-called (page 29 M) in the later Tertiary, shows that it was at least one hundred and nine feet above its present level. The eastern part of this area, and indeed the whole of the Carboniferous basin, was probably higher; at all events, it seems certain that Prince Edward Island was, in the early glacial period, a part of the mainland. A large portion of Northumberland Strait is now from sixty to one hundred feet deep only, so that an uplift of one hundred feet alone would lay bare nearly the whole intervening passage from Richibucto Head and Cape Wolf to Pictou Island. Subsidence may have been inaugurated at the time the Northumberland glacier reached its maximum thickness and extent, or soon afterwards, but of this there is no evidence. Certain facts point to the still greater elevation of the south-eastern part of Northumberland Strait, or rather of the area lying between Prince Edward Island and the axis of the isthmus of Chignecto than that indicated above as referred to on page 27 M.

On north side of the Bay of Fundy.

The north-west coast of the Bay of Fundy seems also to have been higher in some places than at present, in the early part of the glacial period. At St. John harbour and westward to Grand Manan Island, the evidence shows that the Pleistocene land ice extended beyond the existing coast-line into the depression of the Bay of Fundy. Partridge Island in St. John harbour, distant a mile from the mainland, is glaciated by land ice, and Campobello and Grand Manan islands have also been similarly overridden by it. As the passage between the mainland and Grand Manan is 45 to 50 fathoms deep and the island about four hundred feet high, it follows that either the ice which moved out toward it has been quite thick, or the coast border stood higher relatively to sea-level than the present. The latter view is in accordance with the facts obtained along the coast of other parts of New Brunswick. But that the ice covering of the earlier Pleistocene period west of St. John harbour consisted of one confluent massive sheet, is a theory not sustained by the evidence. For example, Passamaquoddy Bay, which is 20 to 30 fathoms deep, was filled by an ice-mass at this period which overflowed Deer and Campbello islands, from 200 to 250 feet high, and also Letite Peninsula, in radiating lines.* This does not betoken a

*Ann. Report Geol. Surv. Can., vol. IV. (N.S.), 1888-89, page 48 N.

confluent ice-sheet moving into the Bay of Fundy. While, however, the ice may have been sufficiently massive to cross the passage between the mainland and Grand Manan with existing or higher levels of the land, there are reasons for believing that this island itself was not as high in the later Tertiary and early Pleistocene, as at present relatively to the mainland. Like the Cobequid Range and other ridges of intrusive rocks, it is not improbable that it has been undergoing a slow differential uplift before and since the glacial epoch. The diverse courses of striæ along the coast of the Bay of Fundy and on the West Isles, lend countenance to the view that the ice cannot have been so heavy and massive as to move out into the Bay of Fundy and override Grand Manan with the present levels, and, therefore, either the mainland has been higher with respect to sea-level, or the ice much more massive than other facts would warrant us in believing.

Probable height of the land at mouth of St. John River at this stage.

It has been shown on page 25 M that the land at the mouth of the St. John River was 200 feet and upwards higher in the later Tertiary than at present. During the period of maximum extension of the ice, it was probably not very far different from this. There is no evidence here or elsewhere in Eastern Canada of any changes of level having occurred between the later Tertiary and the period of maximum ice accumulation; and unless it be that the subsidence, which culminated in the Leda clay period, had then commenced, we know of no other changes of level which could have taken place. It was not till the last stage of the ice age in this region that any facts become available showing the attitude of the land with respect to sea-level.

Height of the Region at the Departure of the Pleistocene Ice.

Attitude of the region, relative to sea-level, at the close of the glacial period.

Soon after the glaciers of the eastern provinces of Canada reached their maximum extension, it would seem that a subsidence of the coast border—or, more correctly speaking local subsidences of the coast border—set in, accompanied by an amelioration of climate, while the glaciers began to diminish. This changed attitude of the land surface and the thinning and breaking up of the ice into still more local sheets, caused it, in many places, to move in different directions from those pursued in the earlier stage of its existence. Concomitantly with the movements of these local glaciers, masses of floating, or sea-borne ice, were carried in different directions by marine currents. In some bays and straits the floating ice formed packs, or ice-jams which seem to have been capable of striating the rocks on which they grounded in a manner scarcely distinguishable from the markings produced by land

ice. These ice-jams appear to have been similar to those described by arctic voyagers as occurring in Smith's Sound and other straits on the west coast of Greenland.

The height of the coast border with respect to sea-level at this stage of the Pleistocene can, in some places, be fixed with tolerable exactness from the position of striæ supposed to have been produced by floating ice on the rock surfaces. Even at this stage the land would seem to have been still subsiding, at least along certain portions of the coast, for marine terraces of Leda clay and Saxicava sand are found at greater elevations than the striæ or markings produced by floating ice, and are undisturbed by ice-movements though subsequently formed. Indeed, it is tolerably certain that not till some time after the final disappearance of the ice from the coast districts, and perhaps also from the interior, did subsidence cease and the post-glacial rise of the coast borders set in.

Brief descriptions of the striation produced by floating ice, in connection with the facts indicating the attitude of the land with respect to sea-level will now be given.

At Trois Pistoles, Quebec.

At Trois Pistoles station, Intercolonial railway, fine scratches parallel to the course of the St. Lawrence Valley here, and also cross stri , the latter broken and irregular, were observed on rock surfaces about 100 feet above sea-level. These are attributed to the action of floating, sea-borne ice, showing that the land was, at least, 100 feet lower at that stage of the glacial period than at present.

The ledges on which these striæ occur have a thin sheet of boulder-clay resting on them which was covered with Leda clay and Saxicava sand subsequently. A deep trench has since been cut in these deposits by a stream flowing over the ledges. On both sides of the excavation the marine deposits, which here form an extensive terrace, lie undisturbed by glacial action, and show no boulder-clay or other glacial products interstratified or overlying them. The striæ have evidently been formed first and the ice which produced them has probably retired before the marine deposits were laid down. The fossiliferous Leda clay and Saxicava sands of this part of the St. Lawrence Valley seem, therefore, to be later than the ice period.

At Cape Gaspé.

Along the south-west side of that narrow peninsula terminating in Cape Gaspé, irregular striæ, formed apparently by some jumping body, occur. The striæ or markings were observed at the following places: The west end of the road leading to Griffin Cove, N. 67° E.; at Little Gaspé, one mile north of Grand Grève, 75 feet high, N. 13° E., N. 23° E. and N. 28° E., and at Grand Grève, 75 to 100 feet high, N. 23° E. These striæ occur on ledges sloping westward towards Gaspé Bay. In

places they are one-fourth of an inch deep or more, and have a gouged out appearance, but do not exceed from two to three feet in length, the majority being from three to nine inches. They are both fine and coarse and have evidently been formed by drift-ice jammed into Gaspé Basin when the coast stood from 75 to 125 or 150 feet lower than at present.

At Baie des Chaleurs.

On the south-west side of the Baie des Chaleurs, along the Intercolonial railway, from Jacquet River to Elmtree River, two or more principal sets of striæ occur. The earliest are heavy, showing an eastward movement. Crossing these nearly at right angles, and also at right angles to the coast line, are numerous fine striæ evidently formed by ice which was pushed against the land. On examining these striæ in detail, it is found that the stoss side is invariably towards the bay. Where they cross ledges with deeply cut east-and-west grooves, the ridge of rock between each groove is found to be stossed on the shoreward side. The greater number of the courses vary from S. 20° E. to S. 20° W.; but as we approach Elmtree River, where the coast-line curves round to the south, the courses of these fine striæ are found trending from S. 36° W. to S. 40° W. On exploring the district as to the extent of rock-surface covered by these fine striæ, it becomes evident that they are confined to a certain zone which is from 60 to 140 or 150 feet in height above sea-level. Below the 60-foot contour line, none of these fine striæ were found, although exposures showing the west-to-east striation are abundant; nor could any be discovered above the 150-foot contour-line. Rock surfaces examined in some of the back settlements, where striated ledges from 150 feet up to 500 feet high occur, were found to be without any of the fine striæ referred to upon them. But it was only at wide intervals that exposures of striæ were noted in these higher grounds.

The conclusion to be deduced from these facts, therefore, is that the fine striæ were made by heavy ice-jams impinging against the coast border while it stood from 75 to 150 feet or more lower than at the present day.

The marine terraces along the south side of the Baie des Chaleurs, indicate that they have been formed subsequent to the stage of the glacial period when these fine striæ were produced, as the deposits in certain places rest on the glaciated surface undisturbed. These marine beds (Leda clay and Saxicava sand) occur at all elevations from sea-level up to 200 feet, in the Baie des Chaleurs basin. It seems probable, therefore, that at the period of the formation of these fine striæ the coast border had not quite reached the lowest stage of the post-glacial subsidence.

In southern part of Gulf of St. Lawrence.

A considerable number of facts from eastern New Brunswick, north-western Nova Scotia and Prince Edward Island have been obtained, the details of which are given on pages 79-83 M, all tending to show that floating ice, or rather heavy ice-jams ground over portions of the Isthmus of Chignecto and the coast districts of Prince Edward Island during the closing episode of the ice age. In order that floating ice might perform this work, it is necessary to suppose that the coast of the mainland was from 125 to 150 feet, and Prince Edward Island 75 to 80 feet lower than at present. This subsidence was probably unequal in different parts of the Carboniferous area during the glacial as well as the post-glacial period. Differential oscillations in the Isthmus of Chignecto have been referred to on page 27 M, and similar movements are evidenced by the striæ of the closing stage of the glacial period in the central part of the New Brunswick Carboniferous area, where there has been an apparent swerving from the easterly course of the earlier stage to a northerly course in the closing stage, coincidently with the progress of the subsidence, as recorded on page 102 M.

At St. John, New Brunswick.

At St. John harbour, unequivocal proofs have been found of the lower attitude of the coast border during this stage of the ice age. On the west side, a bank of boulder-clay from forty to sixty feet in height extends along the beach from Negrotown Point to Duck Cove, a distance of a mile and a half or more. This boulder-clay has been deposited by land ice which came from the north, the materials belonging to rocks lying in that direction. It is partially stratified, or rather contains intercalated seams of stratified clay, which are fossiliferous in some places. A section of the bank, about a quarter of a mile west of the Negrotown Point breakwater, gives the following series in descending order:

Section of boulder-clay containing fossils, at Negrotown Point.

1. Commencing at the summit—typical boulder-clay, unstratified, containing boulders two or three feet in diameter, most of them glaciated. Thickness eleven feet.

2. An irregular, wavy, lenticular seam of stratified boulder-clay, not in horizontal position, varying in thickness from a few inches to a foot or more.

3. Boulder-clay, the same as No. 1, and containing similar boulders, but apparently bedded, or rudely stratified, in some places. In this division of the series the following species of marine shells were found:—*Yoldia (Leda) arctica*, abundant and well preserved, often with the epidermis on, *Balanus crenatus* (fragments), *Saxicava rugosa*, *Mya arenaria* (a single valve), *Macoma calcarea*, *Nucula tenuis* (much broken), *Buccinum* sp.? probably *undatum* (a fragment), etc. All the species except *Yoldia* are quite rare. The fossils appear to be

indiscriminately scattered through the mass. Thickness of this part of the boulder-clay six to ten feet.

4. Stratified, dark red, tough clay, distinctly laminated, with a few boulders of the same kinds of rocks as those met with in the unstratified portions. The whole bed irregular and wavy, not in a horizontal attitude, and somewhat lenticular, or rather not maintaining the same thickness for any distance. Layers of this division of the series are sometimes seen to run up obliquely into and terminate in the unstratified boulder-clay immediately above, and in other places apparently to graduate into it. Scattered throughout are shells of *Yoldia (Leda) arctica*, well preserved, often, in the bottom, with the valves closed, and the epidermis on ; *Nucula tenuis* (broken), *Balanus crenatus* (fragments), *Saxicava rugosa*, *Macoma calcarea*, *Buccinum* and *Mya* (fragments), and one or two undetermined species. Thickness, four feet.

5. The height of the whole bank here is about forty-five feet above the beach, so that there is still nineteen or twenty feet of it below division No. 4. But this portion is concealed from view by land-slides. From the appearance of the bank, however, it would seem that a thick bed of unstratified boulder-clay underlies the stratified seam No. 4, whether containing other stratified layers and fossils it is at present impossible to say.

At the Fern Ledges, the boulder-clay bank is upwards of sixty feet in thickness, and also contains stratified seams of clay, though none have yet proved fossiliferous.*

The inferences deducible from the foregoing facts in reference to the fossiliferous boulder-clay at Negrotown Point are, that in the later stages of the glacial period the land was subsiding, and that the subsidence had reached one hundred feet or more below the present level.

The western part of the boulder-clay bank is overlain by fossiliferous Leda clay and Saxicava sand forming a consecutive series. As the latter deposits are nowhere in this region overlain or interstratified with boulder-clay, it is evident that the ice had retired, at least from the coastal and submerged districts, at the time of the deposition of the Leda clay and Saxicava sands. These deposits occur as terraces up to a height of from two hundred and twenty to two hundred and thirty feet above mean tide level, and it would appear, therefore, that the land along the Bay of Fundy coast continued to subside after the fossiliferous portions of the boulder-clay described above were laid down.

The data relating to the attitude of the coast border in the later or closing stage of the glacial period, therefore, indicate that subsidence Genera statement regarding the

*Ann. Rep. Geol. Surv. Can., Vol. IV., (N.S.) 1888-89, Part N. ; Bull. Geol. Soc. of America, Vol. IV., pp. 361-370.

altitude of the region at close of glacial period.

had so far advanced that the land stood from one hundred to one hundred and fifty feet lower than at present on the mainland of New Brunswick, with perhaps a somewhat less amount in Prince Edward Island, the movement being apparently differential. This subsidence seems to have continued after the close of the glacial period, and did not reach the point of greatest depression till the deposition of the Leda clay. How long it remained at the lowest level it is impossible to say, but if deposition of sediments and subsidence are concurrent phenomena, as is usually held, the marine border must have continued at the stage of maximum depression for some time.

Be this as it may, the subsidence was followed by an upward movement of the land. This movement progressed, as is evidenced by the nature of the deposits around the coast borders and the character of the fossils entombed therein, until the land reached an elevation with respect to sea-level somewhat higher than it is at present. This may be regarded as closing the Pleistocene, or first, division of the Post-Tertiary.

Pleistocene or Post-Glacial Upheaval of the Coast Borders.

Altitude of the coast border at commencement of post-glacial rise of the land.

The attitude of the land at this stage with reference to the present sea-level may be approximately obtained by the addition of the figures in the second and third columns of the table on pages 22-25 M. Those in the second column representing the existing height of the Pleistocene shore-lines or the amount of the post-glacial upheaval less the subsidence of the recent period, are accurate within a small limit of error ; but those in the third are meagre and indefinite. In measuring the heights of shore-lines we used a Y level and rod, two or three aneroids and a hand level. The barometric work represents the mean of a number of observations taken at each locality, and the railway levels are from the profiles of the Intercolonial, Prince Edward Island, Shore Line and Springhill and Parrsboro' railways, the difference between datum and mean tide level being worked out as carefully as possible.

The methods adopted in this investigation were :—first, to trace out a wave-cut terrace, or one formed of sedimentary material, for some distance along a coast or estuary until we were certain it really represented a shore-line. Having ascertained this, measurements were then carried out in the manner most practicable.

This upheaval probably differential.

A comparison of the facts relating to the upheaval of the region embraced in the south-western embayment of the Gulf of St. Lawrence during the Pleistocene period, leads to the conclusion that it was unequal or differential throughout. At first it would seem as if there must have been two systems of upheaval independent of each other,—

one a general movement of the entire region, though somewhat unequal in different localities; and a second which was local and confined to hill and mountain ranges, to which the term orogenic might properly be applied. The latter is exemplified in the uplift of the Cobequid Range and the crystalline belt of southern New Brunswick bordering the Bay of Fundy, described on a previous page. In both of these ranges there appears to have been a slow secular upheaval which had its beginning far back in geological time independent of the oscillations of the Pleistocene period. Was this a separate and distinct movement from the latter, or were they both a part of the general crustal oscillations which characterize the eastern border of the continent?

Uplif greater in the regions of crystalline rocks than in flat Carboniferous area.

An examination of the height of the shore-lines in the second column of the table, in connection with the geological map of the older rocks shows that these are highest in the regions of old crystalline or altered and disturbed strata and lowest in the Carboniferous basin where the rocks lie nearly horizontally and where little or no disturbance has occurred. Prince Edward Island and the Magdalen Islands lie nearest the centre of this Carboniferous basin and, accordingly, we find the Pleistocene uplift to be less there than on the mainland. It is possible there may be a centre of least oscillation or zero point to the north of Prince Edward Island, from which the oscillations increased towards the pre-Carboniferous rocks on either side. Low undulations, or anticlinals and synclinals traverse the Carboniferous strata, and the dips become higher as we approach their limits, indicating greater disturbances or oscillations of the older rocks beneath.

Where highest.

From the table it will also be observed that the post-glacial shore lines are highest at Gaspé, Dalhousie, Indian or Lutz Mountain, Hillsboro', St. John, etc., and on the Magdalen Islands they were also found to be higher than on Prince Edward Island. In all these places a local or orogenic uplift would seem to have taken place as well as the general Pleistocene uplift, thus raising them above the normal gradient similarly to the shore-lines in the Cobequid Pass referred to on page 30 M. Investigation show these ridges and hills to have a central mass of intrusive rocks (dolerite or diabase, felsite, etc.), to the presence of which in all probability the differential movement may be due.

This fact may be taken as indicating that shore-lines on the slopes of isolated crystalline ridges or hills are unsafe guides as to the general post-glacial uplift of the region.

Local or general oscillations.

It will be observed, further, that the general Pleistocene oscillations not only involved the larger portion, if not the whole, of the Carboniferous area, but also the rising crystalline ridges and mountains

locally. For example, the marine shore-lines found throughout the region prove that a general upheaval, though unequal, took place in the Pleistocene, simultaneously, or nearly so; but the local or orogenic uplift of the Cobequids and other local ridges proceeded concurrently, and apparently continued after the general upheaval ceased. But if the supposed local and general upheavals were due to separate and distinct causes, should we not expect to find the latter more uniform throughout this region, especially in that portion occupied by Carboniferous rocks, instead of diminishing towards a central or pivotal point north of Prince Edward Island, as it appears to have done? The fact that this upheaval was greater in the vicinity of the crystalline hills and ridges and gradually lessened as we recede from these, certainly indicates that the orogenic movement affected the Carboniferous basin also. For these reasons it is assumed that the two really belonged to the same system of oscillations, and are effects of the same cause or causes, the apparent difference being due primarily to the fact that the forces producing the upheavals did not at all times exert the same amount of pressure; that is to say, there would be periods of almost paroxysmal intensity when they would affect the crust over large areas and a general upheaval would take place such as that of Pleistocene times. These would be followed by periods of comparative repose, during which slow subsidence would go on, this being the general tendency of the crust from its own weight. While this secular subsidence was proceeding, whatever lateral strain there was imposed on the crust would find relief in linear upthrusts such as those of the Cobequid Range, the crystalline belt of southern New Brunswick and other minor ridges, these local orogenic uplifts being merely correlative movements of the gradually subsiding wider areas of the Atlantic coast border as it sought a position of static equilibrium. This relation is well exemplified in that existing between the secular subsidence of the recent period, as shown by the drowned peat bogs, etc., along our coasts and the slow, progressive uplift of the crystalline ranges bordering the Bay of Fundy and other parts of the Atlantic coast referred to.

Probably only one system of oscillations.

Granting this theory to be correct, it serves to explain the supposed local and general oscillations of level which occurred in this region in the Post-Tertiary period, and probably, with some modification, in preceding geological ages. The apparent decreasing oscillation of the Carboniferous area from the circumference towards the centre, makes it appear as if the tangential force had partially spent itself in that direction upon these undisturbed, unaltered rocks; though why this area should have occupied a more stable attitude than the belts of

older rocks surrounding it is not evident. The breadth and horizontal position of the strata may have been one cause. In this last respect they differ from the older strata bordering them, which are often upturned at high angles. The Cambrian slates of St. John, N.B., which are nearly vertical, exhibit slips and displacements that have occurred since their surfaces were striated by Pleistocene ice, the uplifts being mostly, so far as observations have extended, on the seaward side. None of these displacements were seen to exceed from two to five inches, nevertheless, slips of even this small extent, if numerous, as they appear to be in these slates, when added together give a total of many feet. This is doubtless one way in which local upheavals take place.

Dislocations in Cambrian slates at St. John.

SUBSIDENCE IN THE RECENT PERIOD.

The Recent Period was inaugurated with a land surface along the Atlantic coast border somewhat higher, in many places, than at the present day. A differential subsidence of a small amount has taken place since, and may still be in progress, but with a diminishing tendency. The facts on which this inference is based are the sunken peat bogs and forest beds, originally formed in shallow basins around the coasts, the margins of which are now being eroded by the sea.

Subsidence in the recent period.

The extent of this subsidence as given in the third column of the table is more or less problematical, except in the region at the head of the Bay of Fundy. Here we have good evidence that there was, at the west end of the marine ship railway, a subsidence of 10·80 feet ;* at Aulac Station, Intercolonial railway, 79 feet, and at Edgetts Landing, in the mouth of the Petitcodiac River, 15·32 feet, below mean tide level. The figures for Aulac station are from borings for a well sank there under the direction of P. S. Archibald, Chief Engineer of the Intercolonial railway, (see diagram, p. 129 M). This boring discloses, in descending order, 80 feet of marsh mud, 20 feet of peat, etc. The great subsidence at this place is due to a fault along the north-west side of Westmoreland Ridge, which lies a few hundred yards to the south-east of Aulac station. This ridge trends north-east and south-west, is 140 feet high, and consists of Middle Carboniferous or Millstone grit rocks dipping S.E. $<$ 30°. The downthrow or displacement is 364 feet, that is, assuming the present surface of the ridge has not suffered any appreciable denudation, if it has, the amount must be added to the above figures. How much of this displacement occurred before the glacial period and how much since, it is difficult to tell; but in the recent period, *i. e.* since the

At head of Bay of Fundy.

Displacement of beds at Aulac.

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*Acadian Geology. Supplement, 3rd ed., page 13.

peat beds began to grow, it has been 79 feet below mean tide level. Has this downthrow or subsidence been accompanied by a correlative upward movement in the adjacent district? It seems possible to give an affirmative answer to this question.

Head of Bay Fundy, a great oscillating area.

It was stated on a previous page that the region around the head of the Bay of Fundy has been remarkable for great changes of level. The subsidence or downthrow at Aulac is doubtless related to the uplift of the Westmoreland Ridge and of the parallel ridges lying between it and Petitcodiac River. These all bear evidence of differential upheaval of a greater or less amount since the glacial period. Striæ are found on the summits of these ridges 300 or 400 feet high, evidently produced by the land ice referred to on page 27 M. To enable this ice to flow off the axis of the Isthmus of Chignecto in a south-westerly direction into the Bay of Fundy and produce these striæ in its passage, the land around the head of Chignecto Bay must have been lower relatively, for no elevation exists to the north or north-east sufficient to give it impetus to override these ridges with the levels of the present day. Hence it is inferred that they have sustained a post-glacial, differential uplift which is doubtless complementary to the subsidence shown to be going on in other portions of the same region.

Subsidence as evidenced by sinking peat bogs.

The slow subsidence in progress in several places around the south-western embayment of the Gulf of St. Lawrence in the recent period, as evidenced by the sinking of the peat bogs, is probably not general, although its occurrence along the coast borders of the Carboniferous area and on the north-east side of Prince Edward Island in localities where there is much less oscillation than around the head of the Bay of Fundy, would indicate that it may be. Indeed, it would appear to have altogether ceased locally on some parts of the coast, but continues in other places, though at a very slow and apparently diminished rate, showing, however, that the coast border has not yet reached a position of equilibrium.

Remarks on hypothesis of ice-load causing subsidence.

In reference to the hypothesis of ice-load weighing down the crust at the time of the Pleistocene subsidence; while this is not inconsistent with the facts and inferences brought forward in preceding pages, it does not seem to be required for the explanation of the phenomena in this region. The great difficulty appears to be not so much to account for subsidence, which is the natural tendency of the crust, as for the upheaval of the larger areas. It has been shown on a preceding page, that during the epoch of ice accumulation, at least, the coast region stood higher than at present, and that the period of melting and retirement of the Pleistocene ice was also the period of subsidence. If this ice, by its weight, had been capable of causing a sinking of the

earth's crust, it might naturally be supposed that such a movement would have coincided with the ice accumulation, and an upward movement should have occurred during the melting period as the crust became relieved of its weight. On the contrary, however, the coast border seems to have remained at a low level long after the retirement of the ice, that is to say, during the time the Leda clay and Saxicava sands were being deposited. All the evidence available tends to show that in this region the Pleistocene ice was not of sufficient thickness and weight to sensibly affect the crust of the earth, even if the hypothesis regarding its sensitiveness to load be tenable. It may be added, that the depression of the recent period just described, which has been going on at a time when, as the evidence hows, no ice-covering existed in the region to affect the crust by its weight, materially weakens the force of any arguments that may be advanced in favour of the hypothesis.

Classification.

In this report the general term Post-Tertiary or Quaternary will be used, and it is intended that it shall comprise the whole series of superficial deposits from the close of the Tertiary or Pliocene up to the present. The Post-Tertiary, according to the best authorities,* is divided into the Pleistocene and the Recent or Pre-historic periods. The former is made to embrace all the deposits from the base of the boulder-clay to the summit of the Saxicava sands; the Recent includes the formations lying above the latter. Classification

The Pleistocene of the region under review may, perhaps, be subdivided stratigraphically, if not palæontologically, into two periods or stages,—one characterized by extreme glacial conditions, when glaciers occupied the land and floating ice the adjacent seas, and when life, except that of an arctic character, was very scanty. The deposits of this period are boulder-clay, moraines, osar, glaciated boulders, etc. This might be called the glacial period proper. Fossils occur in these glacial deposits on the Bay of Fundy coast at Saint John, New Brunswick, and in the Saint Lawrence valley at Rivière du Loup, Isle Verte, etc. The shells denote a highly arctic climate, or rather a temperature of the adjoining sea as low as that now prevailing on the coast of Greenland. Subdivisions of the Pleistocene First division of the Pleistocene.

The second division of the Pleistocene may be made to include all those stratified sands, gravels and clays overlying the deposits of the Second division of Pleistocene.

*Sir A. Geikie, Text Book of Geology, 3rd ed., 1893.
Dr. James Geikie, The Great Ice Age, 3rd ed., 1894.
Prof. J. D. Dana, Manual of Geology, 4th ed., 1895.

above designated glacial period and underlying the formations of the recent period, and consist of (1) the marine deposits, Leda clay and Saxicava sands, which are a coast and estuarine series lying below the uppermost shore-line of the post-glacial submergence; and (2) the fresh water deposits occurring on the higher levels. These are probably of contemporaneous origin. The Leda clay and Saxicava sand are usually fossiliferous, especially the first-mentioned, and contain, in certain localities, an abundant marine fauna, the principal species of which exist in the off-shore or deeper coast waters of eastern Canada and Labrador at the present day. A small part, probably about ten or twelve per cent, of the whole assemblage, is not found on these coasts now, and occurs only in arctic and sub-arctic seas. Taken as a whole, the marine fauna of the Leda clay and Saxicava sand, while denoting a more rigorous climate, or rather a somewhat lower temperature of the coast waters than prevails in the region at present, nevertheless, evinces considerable amelioration from the glacial conditions which preceded it.

Marine deposits.

The marine deposits referred to are usually well defined at the base and summit, and distinct from the boulder-clay beneath and from the formations of the recent period above them. They contain no material which can properly be called glacial, *i. e.*, no boulder-clay or morainic matter interstratified therewith, or overlying them, the sand, gravel, boulders, etc., comprising the series, even the boulder-clay itself beneath, being almost wholly derived from the rock-formations of the district in which they lie. At or near the mouths of rivers, the deposits are always of greater thickness than elsewhere and contain a larger assemblage of fossil shells. That the Pleistocene ice had not wholly retired from the higher grounds of the region when the lower portion of the Leda-clay was deposited seems possible, though no evidences of the action of land or floating ice are shown in the structure of the beds, nor are any disturbances apparent, such as we would expect to find had land ice moved down the slopes subsequent to their deposition, or floating ice ground over the areas occupied by them. In their character and mode of deposition, these are similar to marine beds now being formed on the north side of the Gulf of St. Lawrence and on the coast of Newfoundland. Occurring, as they do, at Bathurst, New Brunswick, and other localities in the maritime provinces, with a vertical range or thickness of one hundred and seventy-five to two hundred feet, without any intercalated or overlying glacial deposits, it is evident they must have been laid down when the extreme glacial conditions of the region had very nearly, if not wholly, passed away.

In regard to the fresh-water deposits, so-called, of the second division of the Pleistocene, which consist of stratified sand, gravel and clay occupying those portions of the region above the highest marks of the submergence of the Post-Tertiary period, no fossil remains have yet been found in them in the maritime provinces of Canada.* They are distinctly above the boulder-clay and morainic material and underlie the peat and marl beds; but are often thin and sporadic upon the higher grounds. Along river-valleys and in lake-basins, also in localities outside of these, they blend insensibly into the sands, gravel and clay of the recent period, so that it is impossible to tell where the one ends and the other begins. The bottom portions of some of these have doubtless been deposited by waters from the melting ice of the glacial period; but no boulder-clay or morainic material has been found intercalated with or overlying them. While, therefore, in the region in question, it seems difficult, if not impossible, to differentiate the stratified deposits due to melting ice from those formed by alluvial and subaerial action, there appears to be no doubt that the latter, viz., rivers, streams, lakes, and atmospheric denudation of the land surface generally, were the principal agents to which these deposits owe their origin. Fresh-wate deposits.

Except when occuring along with osar and moraines, there is usually a tolerably well defined line of demarkation at the base of these stratified, fresh-water deposits, their contact with the true boulder-clay having been observed in many places. Their upper limit, too, is often traceable, especially when they are overlain, as they are in many places in this region, by peat-bogs, shell-marl, etc., of the recent period; but in general their limits are poorly defined and uncertain. It is believed, however, that they have been deposited contemporaneously with the Leda clay and Saxicava sands, and constitute the fresh water equivalents of these marine beds.

As regards the classification of the formations of the recent period, there are here few facts indicating succession in these, as in the Pleistocene, the deposits and their contained fauna and flora betokening conditions of climate throughout the whole period not far different from those now prevailing. In the early stage, however, the land in some portions of the maritime districts at least, stood from ten to twenty-five feet or more above the present level, and the climate, Classification of formations of the recent period.

*In the summer of 1894 the remains of a fish about eighteen inches in length were found at Ryan's brick yard, Fredericton, N.B. It is reported to have been imbedded in stratified clay at a depth of twenty-seven feet beneath the surface of the ground. The skeleton is now in the museum of the University of New Brunswick. The deposits in which the fossil fish was found lie in the valley of the St. John River, and are probably of fluviatile origin, and of post-glacial age.

or rather the temperature of the adjacent waters was warmer. It was at this stage that the marine mollusca, whose habitat is now in the coast waters south-east of Cape Cod, are supposed to have spread northward and settled in certain localities around the coast of Nova Scotia, and especially in the southern embayment of the Gulf of St. Lawrence. In the latter place they still continue to exist.

Two main divisions, marine and fresh-water.

The deposits of the recent period may also be classified into two divisions, marine and fresh-water, supposed to be of contemporaneous origin. Usually they are arranged into two groups, viz.: (1) alluvial, that is formed by the sea, by rivers, lakes, etc., and (2) indigenous, *i. e.* formed by the growth of vegetable or animal matter, as peat-bogs shell-marl, infusorial earth, vegetable mould or humus, etc. Peat has been observed in a great number of places resting on sand, sometimes blown sand (sand beaches) also on shell-marl, while it underlies the salt marshes around the head of the Bay of Fundy. If we regard any of these as of successive formation to others, it would seem that shell-marl, infusorial earth, etc., were first formed or deposited, afterwards beds of peat grew upon these, then the deposition of the marsh mud of the Bay of Fundy tides followed. It is probable, however, that the growth of all the peat bogs in their earlier stages was not strictly coeval, but commenced at irregular intervals, continuing till the present. In general, therefore, it may be stated that in the region in question the whole of the recent deposits, marine and fresh-water, are still in process of growth and accumulation, and the forms of life, animal and vegetable, buried therein are those existing around us at the present day.

General classification of the Post-Tertiary.

The whole series of deposits in the Post-Tertiary of the region under review may, therefore, be classified as follows :—

POST-TERTIARY.	RECENT OR PRE-HISTORIC......	1. Indigenous (peat bogs, etc.) 2. Lacustrine. 3. Alluvial, fresh-water and marine.
	PLEISTOCENE....	1. Stratified sands, gravels and clay, fresh-water and marine. 2. Glacial (boulder-clay, moraines, osar, drumlins, glaciated boulders, etc.)

Tabular statement of deposits in the region.

The general character and succession of the Post-Teritary deposits is shown, so far as it is possible to classify them, by the following table :—

M 3.

DEPOSITS OR FORMATIONS OF THE RECENT PERIOD.

Fresh-water. (a)	*Marine.* (b)
Peat bogs.	1. Dunes, or sand beaches.
. Lacustrine—shell-marl, infusorial earth, etc.	2. Estuarine flats, mussel or oyster beds natural dykes. etc.
3. River-flats, intervales (alluvium).	3. Salt marshes (alluvium).

M 2.

DEPOSITS OR FORMATIONS OF THE LATER PLEISTOCENE.

(a)	(b)
1. River and lake terraces and their accompanying kames, etc. 2. Stratified inland gravel, sand and clay, and kames associated therewith.	1. Saxicava sand and Leda clay and kames formed by marine agency.

M 1.

DEPOSITS OF THE EARLY PLEISTOCENE OR GLACIAL PERIOD PROPER.

Boulder-clay or till, moraines, boulders, erratics, etc.

PRE-GLACIAL OR TERTIARY.

Rotted rock *in situ*, angular boulders, gravel, sand, etc.

Tertiary or Pre-glacial Gravels, Sands, etc.

Pre-glacial materials.

Unstratified materials of pre-glacial origin exist in sporadic masses and detached sheets in many parts of New Brunswick, Nova Scotia and Prince Edward Island, especially in districts occupied by Carboniferous rocks. The glaciation of these flat areas has been of a less vigorous and sweeping character than in the more elevated parts of the country, the ice apparently having been sluggish in movement, passing over the loose deposits and rock surfaces without eroding them deeply. Only from certain low ridges, or from the brows of hills exposed to the full force of the grinding ice did it remove the whole of the residuary material and score the solid rocks beneath. In New Brunswick, the thickest beds of this material met with are near the coast of Northumberland Strait, where in a few instances it was found overlain by boulder-clay, which in turn was mantled by stratified deposits of post-glacial age. Upon the higher grounds of the interior of the province, non-glaciated areas of greater or less extent occur, occupied with irregular sheets of the decomposed material belonging to the subjacent rocks. On the sloping surfaces and declivities, these have suffered more or less transport from glacial and atmospheric denudation and they are, therefore, more uneven and irregular than upon the flat Carboniferous tracts referred to.

In New Brunswick.

In Nova Scotia.

The northern flanks of the Cobequid Mountains in Nova Scotia and the slope between these and Northumberland Strait, are also masked with lenticular, detached sheets of residuary material of greater or less extent. This can be observed east of Halfway Lake, at Rodney, River Philip, Williamsdale, Westchester, Wentworth station, etc., and in numerous places between the mountains and the coast of the strait. In the latter area great quantities of such deposits have been kneaded and moved greater or less distances and changed into a kind of boulder-clay by the Pleistocene ice.

In Prince Edward Island.

In Prince Edward Island, large portions of the loose deposits covering the solid rocks consist of residuary material, and sheets five, ten, and even twenty feet in thickness are not uncommon. Much of this resembles boulder-clay in texture, though without scratched or polished pebbles or boulders, and has evidently been compacted by the weight of the snow and ice of the glacial period, and modified by atmospheric action since. The great bulk of it is, however, in an oxidized condition, showing that it is not a true boulder-clay. Further, it contains no travelled boulders or drift, being wholly local, and the materials are unworn. Beds of it may be seen in several places along the Prince Edward Island railway between Summerside and Charlottetown, in cuttings and gravel pits resting on non-glaciated rock surfaces. It occurs along the coast also in numerous localities, especially at Alberton, Campbellton, Wood Islands, etc., often in banks ten to twenty feet thick. Upon the uplands not infrequently it comes to the surface and forms the soil, having apparently undergone considerable denudation. Transported boulders are occasionally found on the surface.

The occurrence of such extensive sheets of decomposed rocks *in situ* points to the fact of light glaciation in Prince Edward Island, and indeed everywhere upon the Carboniferous area on both sides of Northumberland Strait. If the ice which overrode the island from west to east had been heavy and of much erosive power, it is evident the higher portions would have been greatly denuded and the rock surfaces ice-worn, exposed as it would be to the full onset of the mainland glacier. Instead of this being the case, however, the heaviest beds of residuary material occur on the higher ridges of the central part of Prince Edward Island while the thickest deposits of boulder-clay are found along the coast where they seem to have been produced by the heavy impingement of coast or floating ice against the land.

In Magdalen Islands.

The Magdalen Islands exhibit the most remarkable non-glaciated condition of any part of the eastern provinces of Canada. Each island has a nucleus or central mass of intrusive rocks, apparently thrust up into the Lower Carboniferous, gypsiferous strata, breaking through and throwing these into various attitudes. Around the margins of the islands overlying the Lower Carboniferous rocks, occurs a later series of soft, bright-red sandstones, with false bedding, which for the most part occupies a horizontal position. The crystalline series consist of dolerites or diabases, porphyritic and amygdaloidal felsites or traps, etc., forming conical-shaped hills which rise to altitudes of from 400 to 600 feet. In some places the dykes of these rocks penetrate the overlying gypsiferous series in such a manner as to reduce the whole

to a confused mass apparently without order or arrangement. Upon the surface of the whole lie thick beds of rotted rock *in situ* without any boulder-clay or glaciated material. On the north-east sides of Amherst and Grindstone islands, a few pebbles and boulders were observed which may be foreign to them, but even these were not glaciated. The residuary materials were modified on the surface below the 110- to 115-foot contour line by the action of the sea during submergence, while above that level no trace of marine or glacial action could be observed. Indeed, the whole examination of the surface of the four largest islands, viz., Amherst, Entry, Grindstone and Alright failed to show any evidence of glaciation whatever.* Rotted rock alone, with stratified marine beds up to the highest marks of the Pleistocene submergence, are everywhere, the prevailing superficial deposits; above the shore-line referred to some stratified lenticular sheets, due to atmospheric action, occupy the surface and overlie the residuary material; but the pebbles and debris are mostly angular and unworn.

It is possible, however, that more detailed investigation might result in showing some evidences of, at least the impingement of floating ice against the slopes or coast borders of these islands.

The origin of these residuary products is a question which takes us beyond the limits of Post-Tertiary geology. Their occurrence here indicates that in pre-glacial ages the land surface was, for a great length of time, above the sea. The peat beds found by Sir J. W. Dawson underlying boulder-clay at River Inhabitants, attest to the same fact. Whether the decomposed material formed as thick sheets here before it was eroded by Pleistocene ice, as it does now to the south of the glaciated zone, is not evident. In regions swathed in snow and ice, with the ground frozen to a greater or less depth for five or six months of the year, as the eastern part of Canada must have been previous to, as well as during the Pleistocene and since, there would be a conservative effect, checking and, indeed, practically arresting atmospheric disintegration of the rocks every winter. It is true that the melting period each spring is, owing to the loosening of the beds from the unlocking of the previous winter's frost, one of greater denudation than is usual in non-glaciated or tropical regions, but these conditions last only a short time. On the whole, however, the question of extensive and deep-seated pre-glacial rock decay in these latitudes, may be said to require further investigation before it can be correlated with that of non-glaciated tropical countries.

Origin of these residuary materials.

*Mr. James Richardson says "nowhere could deposits of clay or gravel be distinguished such as are usually attributed to the drift period." (Report of Progress, Geol. Survey of Canada, 1879–80, page 8 G.)

(M 1.) Deposits of the Early Pleistocene, or Glacial Period.

Boulder-clay and Boulders.

Boulder-clay and boulders.

The boulder-clay and boulders of the region are so intimately related and their distribution has been affected to such an extent by the same agencies that it seems best to describe them together. And first it may be stated that no boulder-clay, boulders, or other glacial products have been found upon the higher grounds of the region under discussion, except such as belong to rocks on the south side of the watershed of the north-east Appalachians or Notre Dame mountains, so far as my observations have extended. Upon the coast districts, which were submerged during the post-glacial subsidence, scattered boulders occur which do not seem related to the rocks of the region. These have doubtless drifted from the Labrador coast, from the Magdalen Islands, from Cape Breton, and perhaps from Newfoundland.

Dispersion of boulders, where best shown.

The districts which best illustrate the dispersion of boulders are the Carboniferous area of New Brunswick and Prince Edward Island. Upon these large quantities of boulders of granite, diorite or diabase, felsite, Lower Carboniferous conglomerate, etc., are strewn and embedded in the sheets of boulder-clay of greater or less thickness, a considerable portion of them having undergone transportation long distances across the New Brunswick plain.

Table showing dispersion of boulders in the region.

To show the distribution of boulders in the area referred to, certain localities were selected and the boulders upon a given space in each counted. The following table will illustrate the method adopted. But first a list of boulders from two localities on the pre-Carboniferous belts to the north-west of the Carboniferous plain will be given, to show the relation of the boulders on the two areas. All boulders above a minimum size of three inches in diameter were counted.

At Pleasant Ridge, Northumberland county, on an area fifty feet square the following boulders occur.

Granite	88
Diorite	80
Slate	40
Gneiss	16
Felsite	12
Quartz	4

Near Hayes' Brook, South-west Miramichi River.

Diorite	85
Granite	15
Gneiss	2
Slate	2
Quartz	2

Each locality in the following table represents a measured area of fifty feet square.

No.	Localities.	Gray or red sandstone.	Diorite or diabase.	Conglomerate or grit.	Granite.	Gneiss.	Felsite.	Syenite.	Schists, (mica, hornblende, &c).	Quartz and quartzite.	Slate or argillite.	Epidote.	Trap.	
	NEW BRUNSWICK.													In New Brunswick
1	At Ludlow	94			2		1				1			
2	One mile above Boiestown	176	6		14	2	2							
3	At Cross Creek	78			1				1					
4	At Muzroll's Brook	96	3		1									
5	East of St. John River, opposite Fredericton	33	32	21	9		1			3	1			
6	Near Davis's Landing Brook, 5 miles north of mouth of Big Hole Brook	200												
7	Doaktown, east side of river	137	7		3	1				2	1			
8	" west "	300			2	1								
9	" " ½ mile below last	40	91	1	78		15			9	16			
10	" " in another place	7	34		66	6	10			5	5			
11	Between Doakton and Dunphy's	640	20		17	5	9		3		1			
12	Near Blackville	71	5	1	1									
13	Junction of Renous and Dungarvon rivers	36	9		49	3			3					
14	Below mouth of Dungarvon	18	8		54	14	6							
15	Between Renous and Dungarvon rivers		85		11				3			1		
16	Near Rogersville, I. C. R.	45	8		30	4	6				7			
17	East of Harcourt station, I. C. R.	132												
18	Salmon River, near Castaway River	151			1									
19	" " Gaspereau P. O.	69	14		9		3		3	2				
20	" " Meadow brook	99			1									
21	Garry Settlement, Sunbury county	89	3		6					1	1			
22	Enniskillen, Sunbury county	56	18	7	5		5				9			
23	Rushiagonis "	76	6	3	7	1				1	6			
	NOVA SCOTIA.													
24	On northern slope of Cobequids	7	150			1	36	16	2	2			6	In Nova Scotia.
25	Summit of Cobequids on road to Five Islands	7	39		28		36	59	9		2			
26	On highest ground, South Joggins	56												
27	Margin of Minudie marsh	78					2			1				
28	Near Maccan	221	16							1				
29	At Athol	501	1	34			2	1						
30	Near Springhill, east side	173	9	10	3		3	23	3	2				
31	Maccan River, near foot of Cobequids	96	4					8	1					
32	At Halfway River	35					68			2				
33	Mouth of Sand River	93		3					1					
34	At River Philip	83	6		5				3	6				
35	Four miles north of Oxford	34		2										
36	Near Black River	63								1				
37	North of Thompson station, I. C. R.	43	6				2	18	4	1		1		
38	Near Westchester	45	10	2			28	13	2					
39	On DeBert River road	4	48		1		15	27	6					
40	Near Pugwash	147	5		2									
41	West side of Pugwash River, two miles from mouth	116						1						
42	Two miles west of Conn's Mills	128			1				2				3	
43	Wallace River	181	1		1		2							
44	Near Wallace village	91	1				4	2	1		1			
45	" another place	95		2				2				1		
46	" "	208						2						

In P. E. Island.

No.	Localities.	Gray or red sandstone.	Diorite or diabase.	Conglomerate or grit.	Granite.	Gneiss.	Felsite.	Syenite.	Schists, (mica, hornblende, &c.)	Quartz and quartzite.	Slate or argilite.	Epidote.	Trap.
	PRINCE EDWARD ISLAND.												
47	North Cape....	*	*	....	*	*	..	..	....	*	..	..	..
48	Mills' Point, north-east shore........	*	45	....	75	39	12	..	....	....	5	..	..
49	At Alberton.	*	*	*	*	..	*	..	....	*	*	..	..
50	At Campbellton......................	*	*	....	*	..	*	..	....	....	*	..	..
51	At Ellerslie station, P. E. I. R........	*	*	*	*	..	*	..	....	....	*	..	..
52	At Port Hill....	*	*	*	*	..	..	..	....	....	..	..	..
53	At Coleman station, P. E. I. R. ...	*	*	....	*	..	*	..	....	*	..	..	..
54	At Portage " "	*	....	*	*	..	*	..	....	....	..	..	..
55	At Wellington " "	*	*	....	*	*	*	..	....	*	*	*	..
56	At north-east coast, near Margate	*	*	....	*	*	..	..	....	....	..	..	..

In Prince Edward Island, the boulders were not counted, the different kinds only being noted. The relative proportion of transported crystalline boulders to those of local origin is, however, much less there than on the mainland of New Brunswick.

Crystalline boulders the same on the Carboniferous areas of New Brunswick and Prince Edward Island. From a study of the foregoing table, it is apparent that the transported or crystalline boulders upon the Carboniferous area of New Brunswick and Prince Edward Island, are identical with those upon the surface of the pre-Carboniferous rocks to the west. Upon the latter area no sandstone or grit boulders were met with, and this fact, taken along with others, goes to show the direction of the drift movement, viz., that it was from west to east. Notwithstanding the immense quantities of material transported in this direction, however, everywhere upon the surface of the Carboniferous plain the great preponderance of boulders derived from the underlying sandstones, is especially noticeable. Only in a very few localities near the western margin of the area do the boulders of the older crystalline rocks from the west predominate. Beyond a distance of twenty or twenty-five miles from the margin of the crystalline rocks, the sandstone boulders outnumber all others put together.

In New Brunswick and Prince Edward Island, the most abundant of the crystalline boulders are granite and diorite, which again largely preponderate over all others. Slate and felsite come next, then gneiss, etc. This relative proportion as regards the number of these boulders upon the Carboniferous plain is not far different from that prevailing on the surface of the crystalline rocks themselves, so far as observations have ex ended.

Boulders in Nova Scotia. Turning to Nova Scotia, we find the distribution of boulders in the district occupied by Carboniferous rocks north of the Cobequid Moun-

tains to be somewhat different from that just described. Sandstone and grit largely predominate, and among the crystallines, diorites still occupy a prominent place; but boulders and debris derived from the Cobequid Mountains are elements which have to be taken into account here. Hence the great abundance of syenite and felsite boulders upon this slope, as compared to the portions of New Brunswick and Prince Edward Island to which these observations have reference. Upon the northern brow and summit of these mountains, a few sandstone and grit boulders occur intermixed with those belonging to the underlying crystalline rocks, and an interesting problem has arisen in regard to them. Sir J. W. Dawson explains their presence there by the action of floating ice, and it is possible he may be right. But I have been unable to find any system of glaciation either by land or floating ice which will account for the phenomena without raising other difficulties, some of them insuperable, and have therefore been compelled to adopt another hypothesis (page 29 M this report). The sandstones dip away from the mountains wherever they are seen resting on their northern base, and in some places are found *in situ* well up on the slopes, *e.g.*, at Williamsdale, where they occur six hundred to seven hundred feet high, and west of Wentworth station four hundred and sixty-five feet high. No stossing from ice action was found along the northern slope of the Cobequids, and the inference, therefore, is that neither land nor floating ice has impinged against their summits from the north. On the contrary, wherever glaciation is found, the proofs are not wanting that it is due to ice which moved down-hill northwardly. The Cobequids have been uplifted largely, some parts perhaps wholly, since the Middle Carboniferous age, and certain portions of the sandstone strata have been raised with them. Extensive and deep-seated denudation has removed these strata, except very small patches on the flanks, and scattered boulders of sandstone among the local debris on the summit, which still exist there. Wherever the debris showed ice action, it was found that the sandstone boulders were glaciated similarly to those belonging to the crystalline series underneath, this glaciation, I take it, being all due to local land-ice.

On Cobequid Mountains.

Boulder-clay occurs in low, rolling, or lenticular-shaped mounds near the coast of Northumberland Strait in Cumberland county, Nova Scotia, and Westmoreland county, New Brunswick. These often have a thickness of ten to twenty feet or more. Back from the coast here the boulder-clay, as a rule, becomes thinner and more sporadic in its distribution. Along the northern slope and base of the Cobequids, it is only here and there that it is to be seen, long stretches of the slope being covered with residuary material. On the summit, however, it

Boulder-clay, mode of occurrence.

occurs in sheets of limited extent, local glaciers having apparently had gathering grounds there.

Boulder-clay on Carboniferous area of New Brunswick.

Heavy beds of boulder-clay occur upon the Carboniferous area of New Brunswick which appear to be thickest in the valley of the Northwest and Southwest Miramichi rivers. These valleys, which are pre-glacial, were in the glacial period pretty nearly filled with boulder-clay, containing a large proportion of transported materials, often including boulders from five to ten feet in diameter derived from the pre-Carboniferous rocks to the west. The valleys have since been deeply eroded by the rivers, and the great numbers of boulders lying in them are such as have been exposed in this way. In general there are a greater number of boulders in the lower portions of the valleys than along their upper reaches, which is mainly due to the fact that erosion has been greater there. The beds of these rivers may be compared to an inclined plane, the upper parts being nearly as high as the general level of the country, or of the boulder-clay filling each valley, while the lower portions have been cut down more deeply into it. For example, along the upper parts of the Little Southwest, Renous, Dungarvon, Main Southwest Miramichi rivers, etc., flowing through the Carboniferous plain, the terraces and banks inclosing them become lower and lower with respect to the rivers' bed as we ascend, and it is evident that the rivers flowed at higher levels in early post-glacial times, probably upon surfaces very nearly as high as the general level on both sides of their present valleys. Indeed it would appear that in some places their waters must, at that stage, have diverged from the valleys and inundated certain tracts on either side, remodelling the boulder-clay and transporting boulders. The upper portion of the Renous River then flowed into the Little Southwest by a wide valley along the western margin of the Middle Carboniferous. May not the wider distribution of gravels and clay and the scattering of boulders over the surface of the Carboniferous area have been at least partially accomplished in this way? It would seem that in early post-glacial times, as these rivers debouched from the mountains or higher grounds of the pre-Carboniferous region to the west upon the plain, they spread their waters over the level country by many devious routes, until after a time they became confined to one particular valley. At the present day, they flow along their lower reaches in deep trenches of greater or less width cut into banks of boulder-clay which, in early post-glacial times, filled their valleys to the brim. This feature is especially noticeable along the Miramichi rivers referred to.

Towards the coast of Northumberland Strait, near Miramichi River, the boulder-clay, unlike that of Cumberland county, becomes thinner and more sporadic and in many places is underlain by rotten rock *in situ*.

The western part of Prince Edward Island is covered pretty extensively with boulder-clay in which pebbles and boulders from the crystalline rocks of central New Brunswick and a few from the Middle Carboniferous are embedded. The debris of Millstone grit also occurs in some localities intermixed with the boulder-clay. On the higher grounds of the central part of the island, the superficial beds consist largely of residuary material often from ten to twenty feet in thickness.

Where heaviest beds of boulder-clay occur in P. E. Island.

The heaviest beds of true boulder-clay in Prince Edward Island occur on the coast. Banks of it from ten to twenty feet thick may be seen near Cavendish and Cape Turner, also on the south-west coast near Cape Traverse. Overlying these and strewn over the coast districts, especially on the north-east side of the island, occur a number of boulders, in addition to those transported from New Brunswick, which do not seem related to any of the rocks of the region under examination. How these reached there is a problem. At present it is supposed they have been borne thither by floating ice.

Very interesting deposits of boulder-clay were met with along the north-west coast of the Bay of Fundy, some of which have been described in previous reports.*

Magdalen Islands without boulder-clay.

On the Magdalen Island, a few small crystalline boulders were observed on the north-west sides of Amberst and Grindstone islands; but whether transported, or derived from the central crystalline hills of each could not be determined in the limited time at my disposal. It is not improbable they were borne thither by floating ice when these islands stood at a lower level, though none were found in the sand beaches of the recent period. As stated already, no boulder-clay was found on the four largest islands of the group, viz.: Amherst, Grindstone, Entry and Alright.

Intercalated beds in boulder-clay.

In the study of the boulder-clay of the region, particular inquiry was made in respect to the occurrence of intercalated beds of clay, sand or gravel, or whether there were any other facts tending to show a division of the glacial deposits. Except at Saint John, New Brunswick, however, none were found. The origin of the deposits there has been explained as simply due to local oscillations of the ice-front in a subsiding area, with the margin, for part of the time at

*Annual Report Geol. Surv. Can., Vol. IV., (N.S.) 1888-89. Part N. Bulletin Geol. Soc. of America, Vol. IV., pp. 361-370.

least, *i.e.*, during the local advances, extending some distance beyond the then existing coast line.

In a number of localities where the boulder-clay exceeds a thickness of eight to ten feet, the upper and lower parts exhibit the differences due to oxidation and non-oxidation. A deposit of this kind occurs at Alma, Albert county, New Brunswick,* and similar examples were noted at other localities, showing the upper portion of the boulder-clay to be oxidized, while the lower portion consisted of bluish-gray, compact till. No intercalated beds were observed, however, along the line of demarkation between the oxidized and non-oxidized portions, and the inference is, therefore, that the whole mass is really one bed, the chemical change in the upper portion having taken place since its deposition.

Glacial Striæ.

Glacial striæ.

The following list of striæ, embraces all that have been discovered in the district referred to in this report. An attempt is here made to differentiate those produced by the ice at the period of its maximum extension from the striæ formed when it was diminishing and retireing, the movements at the latter stage having been apparently more local and affected to a greater extent by the minor inequalities of the surface. There are, however, a considerable number of striæ which it is difficult, if not impossible, to correlate in this way, or to assign to any particular stage of the glacial period.

Striæ produced by floating ice, or ice-packs, have been found in a number of places along the coast. These will be placed in a separate group.

The bearings of the striæ are in every case referred to the true meridian, and the elevations to mean tide-level.

Striæ produced at maximum extension of the ice.

Striæ Supposed to have been Produced at the Maximum Stage of Glaciation.

Albert County, N.B.

In Albert Co., N.B.

1. In Dawson settlement, S. 44° E. and S. 57° E. Stoss side to the N.W. Height, 430 feet.

2. On upper cross-road leading from Weldon Creek to Turtle Creek, part of it west of sheet No. 4 N.W., S. 52° E. Stoss side N.W. Height, 225 feet.

3. South of Mary's Point quarry, S., S. 8° W., and S. 16° W.

*Annual Report Geol. Surv. Can., Vol. IV., (N.S.) 1888-89, pp. 24-25 N.

4. A short distance south of road running out to Mary's Point, S. 8° E., S. 10° W., S. 23° W., S. 28° W. and S. 33° W. Distinct and well defined. Slope to N. Height, 110 feet.

5. Still further south, on same road, S. 25° W.

6. Half a mile north of Little Ridge cross-roads, on shore road, S. 7° E., S. 23° W. and S. 28° W.

7. On road to Cape Enragé, about one mile from Cape, S. 23° W. Steep slope to E. Height, 150 feet.

8. Half a mile east of Albert (Hopewell Corner) on Crooked Creek, S. 23° W. Height, 340 feet.

9. Going south from Albert (Hopewell Corner), on cross-road leading towards New Ireland, S. 28° W. Obscure.

10. On road going up from Riverside, through Caledonia settlement (at bend of road), S. 23° W. Height, 770 feet.

11. On road from Riverside, going through Caledonia settlement before reaching cross-road leading towards Albert Mines, S. 2° E., S. 8° E. and S. 12° E.; a short distance beyond, S. 4° E. and S. 12° E. On other exposures near by, S. 2° E., S. 7° E. and S. 3° W. Distinct grooves. Height, 1,120 feet.

12. Further north, at extreme height on this road, a small exposure exhibits, S. 6° E. Height, 1,230 feet.

13. South of Woodworth settlement, one mile above cross-roads, S. 18° W. and S. 23° W. Slope, S. Height, 500 feet.

14. At the top of the hill further up, on same road, S. 18° W., S. 28° W. and S. 30° W. Exposure here shows southward ice-movement very clearly. Height, 590 feet.

15. In Sawmill Creek valley, 2½ miles south of Hopewell Hill, S. 8° W. Height, 500 feet.

16. At upper cross-road, on west side of same valley, S. 7° E. Slope E. Height, 950 feet.

Westmoreland County, N.B.

17. About half a mile north of Catamount siding, I.C.R., in a gravel cutting (perhaps on a boulder),* N. 79° E. Very few signs of glaciation on watershed here. n Westmore and Co., N.B

18. At Boudreau quarry, S. S. 8° E., S. 9° E., S. 13° E., S. 12° E., S. 22° E., S. 24° E., S. 1° W., S. 8° W., S. 11° W., S. 28° W., and S. 38° W. Height, 420 feet. Great ledges striated. Courses persistent.

*The striated boulders noted in this list are such as the ice has apparently ground over while they were held in the boulder-clay, *i.e.*, embedded in it, the striæ being in the same direction as those upon the rock surfaces in the neighbourhood. Such occurrences are common in the Carboniferous areas of New Brunswick, Nova Scotia and Prince Edward Island.

19. On slope facing Petitcodiac River, S. 7° E., S. 12° E., S. 22° E. and S. 38° W. Height, 100 feet.

20. On opposite slope, facing Memramcook valley, S. 2° E., S. 12° E., S. 32° E. The S. 2° E. and S. 12° E. striæ are well defined and abundant. Height, 250 feet.

21. On hill near Dorchester Cape, on road leading from Dorchester to Grand Anse, S. 2° E., S. 8° W. The S. 2° E. set deepest. Stoss side to the N. Height, 300 feet.

22. Along Intercolonial railway, east of Dorchester, five or six miles, S. 2° E., S. 5° E., S. 9° E., S. 14° E., S. 3° W., S. 5° W., S. 8° W., S. 12° W., S. 14° W., S. 20° W., S. 28° W. and S. 42° W. The S. 8° W. striæ are the most abundant, covering the whole surface in parallel lines. Stoss side, N. Height, 100 feet.

23. At Second Westcock, half a mile south of forks on road, S. 2° E. and S. 8° W. Stoss side, N. Height, 320 feet.

24. On westernmost road leading from Second Westcock to Petitcodiac River, about two miles from forks, S. 2° E. Height, 250 feet.

The S. 2° E. course is seen to be remarkably persistent on the ridges at the head of Chignecto Bay.

25. Below Peck's Cove, S. 16° W. and S. 28° W.

26. West of Westcock, on road running south-west in centre of Maringouin peninsula, S. 33° W. Height, 150 feet.

27. Two miles west of Four Corners, on Beech Hill road, S. 2° E. Height, 250 feet.

28. Going out from Sackville by road leading towards Colonial Copper Mine, after passing third brook, S. 8° W. and S. 10° W. Height, 70 feet.

29. South of Colonial Copper Mine, on road coming from Sackville, S. 8° E. and S. 12° E. Height, 353 feet. Further west beyond road crossing, S. 1° W. and S. 18° W. Height, 320 feet.

30. On road leading from Memramcook Valley to Beech Hill road S. 2° E. and S. 8° W. The S. 2° E. set heaviest. Height, 300 feet.

31. On summit of ridge behind Memramcook, S. 18° E. Height, 320 feet.

32. On first east-and-west road north of Rockland station, I. C. Ry., about two miles from Memramcook River, S. 7° E. and S. 12° E., further east, additional sets, S. 17° E. and S. 19° E., and in a third locality near by, S. 4° E. Height, 280 feet. Slope to north. Ice movement apparently southward.

33. At a railway cutting a mile and a half east of Midgic station, New Brunswick, and Prince Edward Island railway, S. 54° E., N.

78° E., and N. 88° E. The N. 78° E. set most numerous and distinct. Height, 160 feet.

34. Near the north end of the Tantramar marsh, on the south-east side of the last mentioned railway, S. 28° W., S. 34° W., and S. 38° W. Slope south-west towards marsh. Ice doubtless moved in that direction. Height only a few feet above the marsh surface.

35. At Westcock, S. 8° W., and at Wood Point quarry, S. 18° W., S. 33° W., S. 43° W. and S. 48° W. Stoss side N. Height, 90 feet.

Northumberland County, N.B.

36. At east branch of Barnaby River, along I.C.Ry. track, N. 86° E. Stoss side W. Height, 207 feet. In Northumberland Co., N.B.

In another place, at first brook south of east branch, Barnaby River, N. 88° E., N. 78° E., N. 76° E., and N. 68° E. Stoss side distinctly W. Height, 250 feet.

37. About one-fourth of a mile north of Rogersville station, I.C.Ry., near end of road going eastward, S. 73° E., N. 86° E. and N. 82° E. Stoss side west. Height, 230 feet.

On this cross-road, near head of Bay du Vin River, S. 82° E., S. 87° E. and N. 88° E. Slope S. W. Height, 280 feet.

38. Half a mile south of east branch of Barnaby River, along I. C. Ry., N. 78° E. and N. 88° E., and in another place, S. 77° E., E. and N. 83° E. Latter heavy. Stoss side W.

39. Two or three miles west of Rogersville station, I.C.Ry., S. 84° E., and S. 78° E. Height, 322 feet.

40. In gravel and rock cutting just north of Rogersville station, I.C. Ry., S. 86° E. Stoss side W. Height, 298 feet.

41. One mile north of Acadieville station, I.C.Ry., N. 59° E. Stoss side W. Height, 290 feet. Boulder clay three to five feet deep on ledge.

42. About a quarter of a mile north of Kouchibouguac River along the I.C.Ry., N. 84° E. and N. 89° E. Stoss side W. Height, 278 feet.

43. Half a mile east of Indiantown, Southwest Miramichi River, on west side of Canada Eastern railway, S. 82° E. and S. 88° E. Near tide level.

44. At Indiantown brook bridge, S. 88° E., S. 86° E., S. 83° E, and S. 78° E. The S. 88° E. set is the most numerous and heaviest.

45. On north bank of Southwest Miramichi River, 135 paces above the mouth of the Renous River N. 87° E. (deep ruts), N. 69° E., N. 68° E., N. 80° E., N. 74° E., N. 73° E., N. 72° E., N. 70° E., and N.

62° E. These striæ have the stoss side distinctly to the W. Height, 10 to 15 feet.

46. Two miles above Derby on the south side of the river, N. 70° E., N. 58° E. These striæ, also later ones produced here, show the influence of the valley of the S. W. Miramichi upon the ice-movement.

47. Along the Canada Eastern railway, at first highway crossing east of Blackville, N. 88° E., S. 82° E. and S. 74° E. Slope to N. E. Height, 50 feet.

48. One to two miles above mouth of Renous River on south-east side of S. W. Miramichi River, S. 74° E., S. 67° E., S. 62° E. and S. 52° E. The S. 74° E. set heaviest. Slope N. W. towards river. Height, 70 feet.

49. One mile east of last place of observation, at bend to south in river, N. 88° E., S. 84° E. and S. 74° E. Height, 40 feet.

50. Five miles and a half below Blackville, on the south-east side of the Southwest Miramichi River, N. 88° E., S. 84° E. and S. 74° E. Land slopes to S.W. Height 55 feet.

51. On Cain's River, on N. side of first big bend above Six-Mile brook, due E., S. 82° E. and S. 72° E., Striæ light. Stoss side W. Height, 128 feet.

52. A short distance below the branch of Dungarvon River coming in from Dungarvon L., in rivers' bank, N. 70° E., Stoss side W.

53. On N. side of S. W. Miramichi R. one mile below Boiestown, N. 68° E. Height, 260 feet.

Queen's County, N. B.

In Queen's Co., N.B.

54. Half a mile E. of Castaway brook, on Salmon River road, N. 78° E. and S. 72° E.

55. Along Gaspereaux River, 7 miles from its mouth, S. 54° E.

56. On west side of Gaspereaux River and half a mile above third brook from its mouth, fine distinct striæ, S. 56° E., S. 58° E., S. 62° E., S. 66° E., S. 67° E. and S. 72° E. Slope S. W. Height, 160 feet.

Kent County, N. B.

In Albert Co., N.B.

57. Between St. Anthony's station and Little Buctouche River, along, Moncton and Buctouche Ry., N. 59° E. Height 195 feet. Several other sets here veering towards the N. indicate swerving ice movement during melting period.

58. In Macdougall settlement, one mile from railway station, N. 63° E. and N. 50° E.

59. East of Pelerin settlement, on Little Buctouche River, N. 59° E. Height, 214 feet.

60. On N. side of Shediac Bay, S. 81° E.

61. On N. Side of Shediac River, just west of Richibucto road, S. 81° E.

62. Less than half a mile south of Harcourt station, I.C.Ry., one set, S. 71° E. Others swerving to the north.

62½. In a rock cutting along I.C.Ry., about 4 miles south of Harcourt station, N. 84° E.

Cumberland County, N. S.

63. On Amherst and Fenwick road, a short distance west of junction with road to Nappan station, I.C.Ry., S. 38° W. In Cumberland Co., N.S.

64. On road leading from Salem to Fenwick, half a mile or so from former place, and just north of first bridge, S. 16° W., Stoss side N.; ledge broken off abruptly on S. side. Height, 450 feet.

65. On road from Fenwick to Baird's brook and thence to Maccan station, I. C. R., on bank of brook, S. 2° E. Stoss side N. Height, 350 feet.

66. A quarter of a mile from Salem, near Leicester cross-roads, S. 18° W. Slope S. Height, 385 feet. Five rods further west, S. 7° E.; still further west, S. 18° W.

67. A mile and a half along Leicester road north of junction with Economy road, S. 62° E., S. 8° W. and S. 26° W.

The last five sets have been produced by ice coming from the watershed on the north, *i.e.* from the Leicester and Maccan heights.

68. On Leicester road, two miles from Economy road, N. 18° E., N. 23° E., N. 26° E. and N. 30° E.

These striæ occur on ledges near the summit of the Leicester heights, but on a northern slope. Land to the south, in immediate vicinity, 50 to 100 feet higher. It seems probable, therefore, that the ice producing these moved northwards mainly by the valley of Shinimicas River. Height, 510 feet.

69. One mile east of last striæ along Leicester road, N. 22° E., N. 23° E., N. 26° E. and N. 28° E. Height, 550 feet.

A few rods to the west of these a good exposure exhibits deep grooves one inch or more in width, N. 8° E., N. 13° E. and N. 22° E. Height, 570 feet.

70. Two and a half to two and three-quarter miles from junction of Little River and Leicester roads, N. 12° W., N. 14° W., N. 18° E., N. 22° E., N. 23° E., N. 26° E., N. 38° E. Height, 380 to 400 feet.

71. On same road at head of Shinimicas River, N. 28° E. Height of ledge, 440 feet.

The ice producing these striæ has also flowed down the valley of Shinimicas River. The stoss side is nowhere well exposed.

72. On going from Leicester road to Oxford by Little River road, on bank of Black River, N. 20° E. or the reverse. Stoss side apparently N. Height, 150 feet.

73. On short cross-road to north-west, three miles south of Mount Pleasant, course N. 18° E., N. 21° E. and N. 23° E, or the reverse.

74. On first cross-road to west on road leading from Oxford to Mount Pleasant (may be on a boulder) N. 8° W. or the reverse. Stoss side apparently north. Height, 270 feet.

The last three sets are on a southward slope, Mount Pleasant being to the north.

75. Along semi-circular road on west side of Mount Pleasant, S. 8° W. and S. 24° W. and a few paces further north, S. 12° W. and S. 32° W., or the reverse. Stoss side apparently to the north. Height, 380 feet.

These striæ are on the south side of the summit of Mount Pleasant, and it seems probable the ice may have moved in the direction indicated into Little River and River Philip valleys.

76. On the north side of the summit of Mount Pleasant along the straight road going towards Leicester road, N. 8° E., N. 7° E., N. 10° E., N. 12° E., N. 3° E., N. 13° E., N. 20° E., N. 2° W., N. 8° W. and N. 12° W., or the reverse.

These striæ are all on the slope of Mount Pleasant facing Northumberland Strait. The finely glaciated surfaces exhibited along the roads mentioned, do not enable us to decide the question of the stossing; on a few of the ledges the stoss side seems to be to the north, and on others to the south. The glaciated surfaces slope northwards from 400 to 280 feet, and the uppermost ledges show, generally speaking, the southern faces stossed, (one is clearly rounded, and the northern face abruptly broken off) while the lower are mostly doubtful. Curving striæ are a common feature on these ledges. The two main courses are the N. 8° E. and the N. 8° W. ones, the latter being those in which the principal curved striæ occur. The N. 8° W. set is the older and deeper.

77. On the east side of Mount Pleasant on the cross-road going direct to River Philip, N. 14° E. and N. 24° E., or the reverse. Height, 360 feet. Slope, northward.

78. On a cross-road one mile south of Mount Pleasant (not on map) which runs westward from the Oxford and Mount Pleasant road, S.

12° W. and S. 18° W., or the reverse. Stoss side, apparently north. Height, 360 feet.

Glaciation of Mount Pleasant.

Viewing the glaciation of Mount Pleasant, as a whole, it seems possible to explain it by supposing the summit to have been a local glacial centre; indeed, the evidence rather points in that direction. The course of the ice northward would take it to the nearest and lowest part of the coast, just west of Pugwash harbour. These striæ, however, run diagonally across the northern slope of Mount Pleasant, and the ice which produced them must, therefore, have been influenced, to some extent, by the valley near its northern base which trends in the direction of the striæ. Were it not for the difficulty of explaining a southward ice-movement here, I would be inclined to say that the whole mountain had been glaciated by ice which came from the north. Whether the ice which produced the easterly-trending striæ in the coast district east of Mount Pleasant, described below, received an impetus from the higher grounds of Leicester road and this mountain, is a question that may be answered in the affirmative. And the evidence seems, further, to indicate southward movement off the Mount Pleasant slopes locally.

79. On the south-east side of River Philip, just below the cross-road leading to Conn's Mills, S. 85° E. Stoss side to the W. Height, 190 feet.

80. About 200 yards west of Pugwash Junction, Oxford and Pictou Branch railway, S. 73° E. and S. 75° E. Stoss side, W.

81. On another rock cutting near Pugwash Junction S. 68° E., S. 76° E., S. 77° E. and S. 82° E. Height, 60 feet.

82. On the east side of Pugwash harbour, on boulders and ledges, due E. and S. 68° E.

83. A mile west of cross-roads, which are two miles north of Thomson station, Intercolonial railway, (perhaps on boulder), N. 73° E. Height, 275.

84. At Mackenzie Point, north of Wallace harbour, S. 62° E., S. 67° E., S. 72° E., S. 74° E., S. 77° E., S. 82° E. and S. 84° E.

These striæ extend along ledges on the shore a distance of 400 to 500 feet, and are well marked.

85. Half a mile south of Wallace village, S. 77° E. Height, 165 feet.

This set is noteworthy as exhibiting older and deeper striæ, then later striæ trending nearly N.

86. On east side of Wallace River, a quarter of a mile north of six mile road (on boulder ?) N. 72° E. Height, 80 feet.

87. At Wallace quarry, S. 83° E., very distinct and numerous, also S. 72° E. The overlying boulder-clay is from five to ten feet deep and contains none but local boulders.

88. On road from Wallace quarry leading straight southward to Deware River, near brook, due E. and S. 72° E.

89. On east-and-west road, north of Scott's Lake, S. 87° E. Slope S. Height, 90 feet.

90. Half a mile north of cross-roads, at Hornsey, S. 82° E. and due E. Slope, S. Height, 150 feet.

91. About two and a half miles east of Wallace station, Oxford and Pictou railway, at a rock cutting, S. 84° E. and S. 86° E. Stoss side, W. Height, 175 feet.

92. About three miles east of Wallace station, O. and P. Br. railway, E., S. 86° E, and S. 88° E. Height, 150 feet.

93. About two miles west of Wallace station, N. 78° E.

94. On east bank of Wallace River, just above railway bridge, S. 72° E., S. 82° E. and S. 83° E. Stoss side distinctly W.

95. On Economy road, west of Westchester, on N. slope of Cobequids (on boulder ?) N. 2° W., or the reverse. Height, 689 feet.

96. On short east-and-west road, a mile, or a mile and a half, south of Purdy's Inn, Westchester, S. 2° E., or the reverse. Stoss side apparently N. Height, 967 feet.

97. On Castlereagh road, half a mile from north end, S. 2° E.

98. Three miles south of Sutherland's Lake, on south-easternmost road, S. 2° E. Stoss side, N.

99. On Economy road near fourth brook crossed west of Thomson station, Intercolonial railway, and Williamsdale road, N. 73° E. Height, 300 feet.

100. On road south of Folly Lake, near border of sheet (No. 4 N.W.), S. 2° E., S. 22° E., and S. 27° E. Stoss side, N. These striæ are on the southern flank of the Cobequids. Height, 650 feet.

101. A few rods further north on the same road, S. 4° W.

102. On a hill on same road further north and near water-parting, S. 22° E. Course of ice here nearly in direction of valley. Height, 725 feet.

On a hill between this and Folly Lake, and slightly higher there are no signs of glaciation.

103. At first cross-road north of Westchester (Purdy's Inn), N. 2° W., or the reverse. Probably on boulder.

104. On Economy road just north-east of Claremont Hill, S. 62° E., S. 78° E. and S. 82° E. Height, 120 feet.

105. On road from Springhill to Salt Springs on eastern slope of hill, N. 2° W. or the reverse. Stoss side apparently to the N., but all things considered it seems probable that the ice moved northward. Height, 310 feet.

106. On cross-roads south-west of River Philip P. O., N. 6° E. Stoss side S.

107. On summit of Springhill, highest point, S. 28° W., or the reverse. Height 610 feet.

108. At Springhill near Coal Mines Creek, on east side of railway track, S. 11° W. A short distance further east, S. 13° W. and S. 26° W.

109. Two miles south of Springhill Mines on road going directly southward ending at branch of Upper Maccan River, and at last cross-road before reaching river, S. 11° W. Height, 300 feet.

110. On road near Intercolonial railway west of Athol station, S. 28° W., S. 38° W and S. 40° W. Stoss side distinctly to N.E. and ledge broken off abruptly to S.W. Height, 150 feet.

111. Going along Upper Maccan River towards Southampton about two miles from end of Mapleton road, S. 68° W., S. 48° W., S. 36° W., and S. 33° W. The S. 68° W. striæ are the oldest and are nearly obliterated. Stoss side not distinct, but appears to be to N.E.

112. On southernmost cross-road in West Brook settlement, light and irregular striæ S. 28° W. Stoss side N.E. Height 350 feet.

A short distance further west on the same road, S. 8° W. to S. 38° W. Stoss side N.E.

These striæ have been produced by a very small local glacier, or a tongue of the larger one which followed a small valley opening into the larger valley of West Brook. The ice producing them does not appear to have ascended the Cobequid Mountains, for, at greater elevations on their northern slope no sign of glaciation was observed, the material being angular, the rock surfaces wherever exposed, jagged and broken, indicating subærial weathering only, while boulder-clay and other evidences of glacier action are absent. Glaciation of northern slope of Cobequids.

113. Along West Brook between two cross-roads and about two miles from the Springhill and Parrsboro' railway (on a boulder *in situ*) S. 58° W.

The three last sets of striæ show that ice from the Springhill district impinged against the northern base of the Cobequids here, but does not seem to have been higher than the 400-foot contour line above sea-level. From this district the ice flowed south-westward filling the inequalities of surface along the northern base of the mountains reaching up the Parrsboro' gap some distance, but does not seem to

have gone through. How far westward along the foot of the mountains the ice extended is not known, as the surface is heavily covered with superficial deposits and no glaciated surfaces were noted.

114. On road from Halfway Lake to Southampton, half a mile out on cross-road on N. W. side, S. 46° W. Height, 180 feet.

115. In Parrsboro' Pass, through which the Springhill and Parrsboro' railway runs, just south of border of sheet (No. 4 N. W.) faint striation S. 12° E. Stoss side apparently to the N.

The latter striæ have been produced by the extreme southern end of the ice lobe which flowed south-westward and southward along and towards the northern base of the Cobequid Mountains here, from the Springhill district and other higher grounds to the north-east, as referred to above.

115½. On road along N. side of Minas Channel, near Spencer's Island, S. 67° W. and S. 70° W.; well defined. Stoss side apparently to the E., ice having doubtless moved westward into the Bay of Fundy.

116. On the road leading from Maccan station, Intercolonial railway, to River Hebert, near Patrick Mine, S. 23° W. and S. 40° W. May be local. Height, 175 feet.

117. On southerly road going from Lower Cove or Boss Point, north of the South Joggins towards River Hebert, two miles out from quarry, and on the east side of the watershed, S. 18° W., S. 26° W. and S. 38° W. Stoss side doubtful. Height, 210 feet.

118. Eighty rods further east on same road, S. 23° W. and S. 33° W. Height, 180 feet.

119. On road going from River Hebert to South Joggins, half a mile from river, S. 62° W. and S. 63° W. Height, 150 feet.

Ice producing these clearly moved south-westward.

120. On the coast of the Bay of Fundy, just south of Two Rivers, S. 33° W., S. 38° W., S. 43° W. and S. 48° W. Height, about 100 feet.

121. Two miles further south, before crossing a brook, S. 36° W., S. 38° W., S. 42° W., S. 53° W. and S. 58° W. Height, 200 feet.

122. Half a mile south of last brook referred to, which is about half way between Two Rivers and Flat Brook, S. 40° W. Height, 100 feet.

123. A quarter of a mile further to the south-west, distinct striæ, S. 38° W. and S. 41° W. Height, 50 feet.

124. Five rods further to the south-west, S. 48° W.

125. Half a mile beyond Flat Brook, S. 43° W. and ten rods further to the south-west, S. 48° W. and S. 51° W. Height, 60 feet.

Eighty rods further to the south-west, S. 40° W.

126. One and a half miles north-east of Shoulee River, S. 43° W. and S. 48° W. Stoss side on N.E. Height, 100 feet.

127. On slope towards Sand River and about one mile from it, S. 33° W. and S. 38° W. Height, 210 feet.

128. Two miles south of Sand River road, S. 30° W., S. 27° W. and S. 33° W. Height, 350 feet.

In another place a quarter of a mile further south, S. 28° W.

Ten rods further to the south-west, a splendid exposure, S. 30° W. and 33° W. Height, 350 feet.

129. Half a mile or more further south, S. 33° W. and S. 35° W. and still further to the south-west, S. 33° W., S. 28° W., etc., numerous. Stoss side to N.E. Height, 380 feet. Small projections on glaciated surfaces of the sandstones with crag-and-tail form, show southward ice-movement. A perceptible veering to more southerly courses is apparent as we ascend the slope of the Cobequids, which is remarkable, and can only be explained on the hypothesis that Chignecto Bay was filled with a local glacier moving south-westerly, whose south-eastern border overlapped the district in which these striæ occur.

Prince Edward Island.

130. At Linkletter's shore, on flat surface, under boulder-clay, distinct striæ, N. 67° E., N. 74° E. and N. 76° E. Stoss side to W. In P. E. Island.

131. Along Prince Edward Island railway track, south-east of Kensington station, N. 71° E. Stoss side W. Height, 116 feet.

132. Along Cape Traverse railway, about one mile from Emerald Junction, N. 75° E. and on another ledge near by, N. 67° E. Stoss side W. Height, 130 feet.

133. One to one and a quarter miles north of Kinkora station, N. 85° E. Stoss side W. Height, 100 feet. From two to five feet of boulder-clay overlies the rock surface, and contains numerous glaciated boulders, all local.

134. Half a mile north of Albany station, S. 78° E. and N. 82° E. Height, 125 feet.

135. South of Albany station, on boulder *in situ* in a gravel pit, which fits into position in a ledge, S. 79° E. and N. 83° E. Height, 80 feet.

136. At Breadalbane station, Prince Edward Island railway, 131 feet high, N. 69° E.

137. Two miles west of Hunter River station, N. 89° E., N. 73° E. and N. 72° E.

138. Where a road crosses railway track about half-way between Hunter River and North Wiltshire stations, S. 87° E., N. 89 E°., N. 85° E., N. 83° E. and N. 79° E. The N. 89° E. striations numerous. Height, 210 feet.

The ice producing these striæ has followed valleys along which the railway runs. The glaciation of the higher grounds in this part of the island has been light, as great masses of rotted rock occur in places.

139. A quarter of a mile east of cross-roads, South Wiltshire, on a small exposure, sloping eastward, N. 82° E. Height, 280 feet.

140. At the end of road between Platt River and Bentick Cove, N. 67° E., N. 85° E., etc.

141. Three quarters of a mile to east of County Line on New Bedeque road, N. 69° E. Height, 200 feet.

142. West of intersection of County Line and New Bedeque roads, N. 77° E. Height, 210 feet.

143. At intersection of above roads, N. 77° E., N. 88° E. and N. 62° E. Height, 250 feet. Slope N.W.

144. North-east of Middleton where road crosses branch of Dunk River, N. 71° E., N. 67° E. and N. 77° E. Height, 55 feet.

145. On Southwest road, one mile and a half south of New Bedeque road, S. 88° E. Height, 150 feet. Slope S.

146. Ninety or one hundred rods east of junction of Southwest and New Bedeque roads, N. 87° E. Height, 170 feet. Slope W.

147. Fifty rods west of County Line on cross-road, one mile N. of Tryon, N. 69° E. Height, 100 feet. Slope, W.

148. Near end of road, N. of Bentick Cove, N. 77° E. Tide level. A few rods further W., N. 67° E.

149. A quarter of a mile east of ferry over Ellis River, N. 67° E.

150. On west side of Sable River bridge, N. 73° E., N. 63° E. and N. 77° E.

151. On east side of Sable River on road to Bonshaw, N. 77° E. Height, 170 feet. Slope W.

152. A quarter of a mile east of Cape Traverse, S. 73° E and S. 71° E.

153. At Point, Cape Traverse, S. 73° E.

154. West of Cape Traverse, S. 71° E.

155. A few yards further west, S. 63° E. and S. 68° E. Still further west, S. 68° E., N. 77° E. and S. 81° E.

156. West of Cumberland Point, S. 75° E. and S. 81° E. On another exposure a short distance to the west, N. 72° E. and S. 67° E. Still urther west, S. 71° E., S. 73° E. and S. 79° E.

157. East of Cumberland Point, N. 73° E. and S. 67° E.

Half a mile further west, S. 73° E.

158. Near small brook one mile and a half north of Tryon Head, S. 85° E. Height, 20 feet.

159. At end of short road west of Paul's Bluff, N. 87° E.

160. At junction of Bedeque road with east branch of Tryon River, S. 85° E., N. 89° E. Height, 20 feet.

161. On west side of Augustine Cove, a quarter of a mile west of small brook, S. 73° E., S. 68° E., S. 81° E. and S. 85° E., distinct.

162. On road east of Albany, ten rods north of Tryon River, N. 87° E. Slope, S.E. Height, 75 feet.

163. At point west of Gordon Cove, S. 63° E., S. 68° E. and S. 55° E.

164. At Boquet Point, S. 81° E., S. 73° E. and S. 63° E.

On another exposure, S. 68° E., S. 76° E., S. 63° E. and S. 79° E. There are two main courses, S. 68° E. and S. 79° E. A little further east, S. 63° E. and S. 73° E.; and still further east, S. 83° E. and S. 63° E. The latter are a quarter of a mile east of Boquet Point.

165. On ledges below high tide level, one mile west of railway wharf, Cape Traverse, S. 81° E., S. 78° E. and S. 55° E.

166. North of Gordon Cove, S. 71° E., S. 68° E. and N. 87° E.

167. At Sea Cow Head, S. 68° E. and S. 81° E. Height, 5 feet.

168. East of Indian Point, N. 87° E.

169. At Simpson's Point, north of Hope River, S. 82° E., S. 86° E., S. 78° E. and S. 89° E. Peculier grooves indicate eastward movement. Height from three feet below high tide level to four feet above it. An excellent exposure.

170. Near head of Trout River, S. 88° E. and N. 80° E. Stoss side, W. Height, 105 feet.

171. Where Millvale road bends northward down Trout River, S. 83° E. Height, 110 feet.

172. New London Bay, one mile north of Stanley Bridge, S. 78° E., S. 68° E., S. 85° E., S. 83° E., S. 73° E. and S. 88° E. Height, from tide level to four feet above it.

173. Old Prince Town road, forty rods north of Margate, N. 65° E. Height, 60 feet.

174. A quarter of a mile north of road end, Mill's Point, N. 67° E.

174. At Mills Point at end of road, N. 65° E.

175. In Malpeque Bay, near end of road west of Mill Creek, N. 75° E., N. 71° E., N. 67° E., N. 79° E., N. 81° E., N. 77° E., N. 69° E., N. 57° E. and N. 59° E. Near high tide level. Striæ numerous and extending across 46 paces of rock surface.

176. Seven hundred and seventy paces west of last mentioned road end, N. 83° E., N. 51° E., N. 40° E., N. 67° E., N. 41° E., N. 65° E., and N. 87° E.

177. North of St. Peter's Bay, near railway station, N. 87° E.

178. On S.W. side of St. Peter's Bay, west of railway station, N. 84° E. Boulder-clay plentiful.

Striæ at St. Peter's Bay.

Three sets of striæ occur at St. Peter's Bay, viz., (1) an easterly set which is the oldest, (2) a northward set made by local glaciers flowing northward from the higher grounds of the island towards the Gulf, and (3) a set parallel to the depression occupied by St. Peter's Bay, and approximately parallel to the N.E. coast of the island, produced apparently by floating ice. None of these sets are, however, very well defined.

179. Near Light House at Souris, N. 87° E., and in a railway cutting east of Souris village, N. 79° E.

On another exposure east of village, N. 87° E. and S. 83° E.

New Brunswick ice on P. E. Island.

No transported boulders occur in the boulder-clay here, the whole of the material being local. The inference may be drawn that the glaciation is also local, but this is, perhaps, incorrect. The non-occurrence of foreign material in the eastern part of the island rather indicates that the ice was of local (Prince Edward Island) origin, forming an outlier of the mainland sheet and moved by the impingement of the latter, thus producing the glacial phenomena noted. If the New Brunswick ice itself had passed over the whole island, instead of only over the western half, where we find boulders and other glacial products from the mainland intermixed with the boulder-clay, we should expect to meet with crystaline boulders embedded and intermixed with the deposits here also. Their absence, except on the immediate coast, where they have been left by floating ice, is otherwise not easily explained.

Striæ produced by local glaciers during closing stage of glacial period.

Striæ supposed to have been produced by Local Glaciers, etc., during the later or closing stage of the Ice Age.

ALBERT COUNTY, N.B.

In Albert Co., N.B.

180. At Hopewell Cape, S. 86° E., S. 82° E. in two places, S. 80° E. due E. and N. 88° E., also further N., S. 22° E.

181. A mile N. of Hopewell Cape, N. 82° E.

182. At Mary's Point quarry, several striated exposures, S. 2° E., S. 3° W., S. 22° E., S. 32° E., S. 37° E. and S. 46° E. Heaviest striæ or grooves, S. 22° E.

183. At point where Cape Enragé road branches off to the east, S. 52° E., S. 62° E., S. 77° E., S. 82° E., due E., N. 78° E. and N. 80° E. Height, 190 feet.

184. Near mouth of Demoiselle Creek, S. 2° E. Stoss side N. Slope, E. Height, 170 feet.

185. At Jasper Creek, on cross-road from Demoiselle Creek to Sawmill Creek, S. 2° E. and S. 1° W. Slope towards E. Height, 580 feet.

On same road further up hill, at height of 610 feet, where slope is towards the N, S. 4° W.

186. On road going west from Curryville, S. 12° E., S. 20° E. Slope, E. Height, 400 feet.

On another good exposure here, S. 19° E. and S. 22° E.

On the same road a little further eastward down the slope, S 20° E., S. 12° E., S. 2° E., S. 8° W., S. 18° W. and S. 28° W.

Twenty feet from this exposure another exhibits, S. 32° E., distinct. Slope, E. Height, 300 feet.

Westmoreland County, N.B.

187. In Weissner settlement, on bank of Bateman's brook, N. 49° E. Flat exposure. Height, 90 feet. In Westmoreland Co., N.B.

188. Along I.C.Ry. track between Painsec Junction and Dorchester road-crossing, just N. of Meadow brook, N. 55° E. May be on boulder.

189. At southern base of Lutz Mt. at cross-road, 3 miles east of Berry's Mills station, I.C.Ry., N. 48° E. Height, 300 feet.

190. Near Chapman, on slope towards Northumberland Strait, N. 42° W. Height, 80 feet. May be on a boulder.

Northumberland County, N.B.

191. At the Tickle, junction of N.W. and S.W. Miramichi rivers, just opposite Beaubair's Island, S. 17° E. and S. 20° E. Striæ light. In Northumberland, Co., N.B.

192. On N. bank of S.W. Miramichi River, just above mouth of Renous River, N.2° E., N. 10° E., N. 22° E. and N. 32° E. Stoss side S.

193. Two miles above Derby on the south side of the S.W. Miramichi River, S. 37° E., N. 28° E., N. 46° E. and N. 43° E.; on another exposure two hundred feet further west, N. 34° E., N. 36° E., N. 40° E., N. 43° E. and N. 46° E. Tide level. The N.E. course seems to have been produced by local ice following the valley of the S.W. Miramichi River here.

194. One to two miles above the mouth of Renous River on the S.E. side of the S.W. Miramichi River, due N. Whole surface of exposure with parallel grooves in this direction. Height, 70 feet.

The two main sets of striæ are well exposed here, one indicating eastward ice-movement, as recorded in No. 45, and the second a later and independent flow northward.

195. Eight miles and a half below Doaktown, along Canada Eastern Ry. track. N. 38° E.

196. Eight miles below Doaktown, along same railway (at 72nd mile post), N. 24° E., N. 30° E., N. 26° E., N. 32° E. and N. 38° E.

197. Five miles below Doaktown, along C.E.Ry., N. 13° E. and N. 28° E.

198. Three and a half miles below same place, along railway, N. 16° E., N. 20″ E., N. 23″ E. and N. 28° E.

The N. 28° E. set most numerous. Height 320 feet.

A few yards further to N.E., N. 18° E., N. 23° E. and N. 33° E.

199. A quarter of a mile above the cross-road at Dunphy's, on the north side of the Miramichi River, N. 24° E and N. 28° E.

200. One to two miles above Blackville bridge in the S.W. Miramichi Valley, in river's bank, N. 12° W. and N. 22° W. These courses are closely parallel to the river-valley here, and may have been produced by river ice.

201. At mouth of Bett's brook, above Doaktown, fine distinct striæ, N. 42° W. (heavy), N. 6° W. and N. 23° E.

202. At Ludlow one mile and a half south of Boiestown, where road and river diverge, on south side of river, N. 42° W., or the reverse.

203. In railway cutting at covered bridge just west of Boiestown, N. 18° E. and N. 28° E. Stoss side, S.W.

204. Along S.W. Miramichi River, on N.W. side of Hayes' brook, N. 28° E., N. 33° E., N. 38° E. and 46° E. Stoss side distinctly S.W. Height, 520 feet. (This is in York county).

Queen's County, N.B.

In Queen's Co., N.B.

205. Along Gaspereaux River, seven miles from its mouth, S. 54° E. Half a mile above the third brook from the mouth of Gaspereaux River, several deep grooves have a bearing of S. 32° E. in addition to more easterly courses. Slope, S.W. Stoss side, N.W. Height 160 feet.

Kent County, N.B.

In Kent Co., N.B.

206. About one mile east of Macdougall station, Moncton and Buctouche railway, on road to Cocagne, N. 18° E., N. 38° E. ; and on another surface near by, N. 38° E. Slope, N.W. Height, 130 feet.

PLATE II.—STRIÆ NEAR HARCOURT STATION I.C.R.
(No. 216, List of striæ;) Course N. 9° E. View from south-west side.

207. One mile south of St. Anthony station, M. & B. Ry., a good exposure, N. 52° E.

208. Just west of Cocagne village, on shore, N. 38° E., N. 43° E.

209. Just north of St. Anthony station, Moncton and Buctouche railway, N. 44° E., N. 49° E. and N. 54° E.

210. Between St. Anthony station and Little Buctouche River, along railway track, N. 39° E., N. 49° E., N. 54° E. and N. 59° E. In another place N. 44° E. Height, 195 feet.

211. Just N. of Little Buctouche River, along M. & B. Ry, N. 19° E. and N. 39° E.

212. At border of sheet (No. 5 S.W.) one mile south of Buctouche River, S. 31° E. Height, 90 feet.

213. About two miles from St. Anthony station, M. & B. Ry. going towards Cocagne River, in Ohio settlement, N. 49° E. Numerous and well defined. Stoss side, S.W. Height, 150 feet.

214. On the north side of Shediac Bay, N. 29° E., N. 39° E., etc.

215. 770 yards south of Harcourt station along the I. C.Ry., on one exposure, fine, curving striæ, the general trend being N. 22° W.

216. 990 yards from Harcourt station and just south of last point of observation, great flat exposures occur in gravel pits on both sides of the I. C.Ry. track, with well marked striæ, N. 27° E., N. 17° E., N. 16° E., N. 13° E., N. 11° E., N. 9° E., N. 7° E., N. 6° E., N. 4° E., N. 3° E., N. 1° E., N. 1° W., N. 2° W. and N. 16° W. These striæ have evidently been produced by ice moving northward, but there is no distinct stossing. Height, about 190 feet.

217. About two miles south of Harcourt station, in a rock cutting, N. 3° E., N. 4° E., N. 5° E., N. 9° E., N. 11° E. (heavy), N. 12° E., N. 19° E., N. 24° N. 29° E., N. 1° W. (numerous), N. 6° W. and N. 21° W. The stoss side is also doubtful here ; but several circumstances favour the conclusion that the ice moved northward.

218. A mile and a quarter north of Adamsville station, I. C. Ry, in a rock cutting, N. 1° E., N. 2° E., N. 3° E., N. 4° E., N, 5° E., N. 6° E., N. 7° E., N. 8° E., N. 9° E., N. 11° E., N. 12° E., N. 13° E., N. 14° E., N. 17° E., N. 19° E., N. 31° E., N. 1° W., N. 3° W., N. 6° W., N. 8° W., N. 16° W. N. 33° W. Stoss side not evident ; but some facts were observed on the south side of the exposure which show that the ice movement must have been northward.

219. On the south branch of Coal Branch, just east of Intercolonial railway track, in an old quarry, N. 9° E., N. 19° E., N. 29 E., N. 32° E., N. 34° E., N, 39° E., N. 42° E. and N. 49° E. Stoss side distinctly to the S.W. Height, 203 feet.

Remarks on swerving and irregular ice movements.

It will be observed that the courses along the S.W. Miramichi, and the Intercolonial railway at Harcourt, Adamsville, Coal Branch, as well as near the coast between Buctouche and Shediac rivers show similar ice-movements. These striæ, it seems to me, have been produced by the ice during the period of melting or retirement, though a few may belong to the earlier or increasing stage previous to its maximum extension. The finer striæ, however, clearly indicate the later movements, when the ice was breaking up into detached sheets and became diverted more and more from its eastward course as it diminished, the movements becoming more conformable to the slopes, and to the trend of the river-valleys. This swerving is a characteristic and noteworthy feature of the glaciation on the Carboniferous plain north-east of the divide between the drainage basin of the St. John River, and of those rivers flowing into Northumberland Strait.

Cumberland County, N.S.

In Cumberland Co., N.S.

220. North-east of Amherst Head, on a boulder, apparently *in situ*, N. 3° W., or the reverse Stoss side, S. Height, 130 feet.

221. Just west of Fenwick, on an exposure, apparently a boulder, on road side, S. 78° W. and S. 73° W. Stoss side, E. Height, 135 or 140 feet.

222. Near a quarry about a mile east of Amherst, N. 12° W. and N. 22° W. Height about 150 feet.

These striæ have apparently been produced by ice which flowed down upon the low grounds of the Isthmus of Chignecto, or into the Pleistocene sea occupying it as a strait, during the retiring stage of the glacial period.

223. One mile south of Pugwash, on the main highway to Wallace, N. 23° E. Slope to S. Height, 80 feet.

224. On the west side of Pugwash harbour, on boulders and ledges, N. 22° E. and N. 45° E.

225. At cross-roads at Victoria, N. 2° E., N. 10° E. and N. 18° E. Stoss side distinctly to the S. Exposure on N. slope. Boulder-clay abundant. Height, 275 feet.

226. On north-and-south road to south-east of Victoria and between two branches of Wallace River, N. 8° E. Stoss side also distinctly S.

227. In Hansford settlement, two miles along road from River Philip, N. 20° E. and N. 23° E. Height, 250 feet.

228. Near cross-roads, half-way between Coun's Mills and Doherty Creek, N. 48° E. and N. 53° E. Height, 25 feet.

229. On east-and-west road at Howard's Mill and a quarter of a mile from the west end or the junction with the north-and-south road, N. 10° E. and N. 40° E. Height, 150 feet.

230. Half a mile south of Wallace, N. 3° E. and N. 2° W. Height, 165 feet. East-and-west courses on same exposure prove that the S.-to-N. set is the latest.

231. On the N.E. and S.W. road along the upper part of Deware River, N. 8° E. Height, 200 feet.

232. On the second road east of Wallace Lake and north of Deware River, N. 7° W. and N. 12° W. Height, 150 feet.

233. At Wallace quarry, N. 2° W., N. 10° W., also N. 3° E., N. 32° W. and N. 54° W. or the reverse.

234. A quarter of a mile south of Wallace station, Oxford and Pictou Branch railway, N. 3° E. and N. 18° E. Slope N. Height, 90 feet.

235. On the road along DeBert River, near the border of the map, and at the height of 620 feet, S. 2° E. and S. 12° E. These striæ are on the S. slope of the Cobequid watershed.

236. North of the cross-roads to the north of the railway track near Wallace station, Oxford and Pictou Branch railway, due N. Height, 220 feet.

237. Just east of Wallace, on shore, striated ledges occur, N. 8° E.

238. On road going from Plaster Cove east of Wallace, to north side of Scott's Lake, at third cross-road, N. 30° E. Slope E. Height, 170 feet.

239. On the easternmost cross-road from Scott's Lake to the Strait of Northumberland, near shore, (perhaps on boulder), N. 36° E.

240. Near by on same road, another set, N. 12° E. Height, 170 feet.

241. On cross-roads at Hornsey, due N. Slope S. Height 45 feet.

242. South of Head of Tatamagouche, perhaps on boulder, N. 2° W.

243. On Lake road, just about south of Head of Tatamagouche, on boulder, *in situ*, N. 12° E. Height, 270 feet.

244. On road running up south side of Mill Brook, N. 3° E.

245. On road east of Wentworth along Higgins's brook, N. 18° E. and N. 7° W.

246. About two miles west of Wallace station, Oxford and Pictou Branch railway, N. 2° E.

247. On east bank of Wallace River, just above railway bridge, N. 28° E. and N. 38° E. Height, 25 feet.

248. Near border of sheet (No. 4 N.W.), and south of Sutherland's Lake, S. 32° E. Stoss side N. Height, 600 feet.

249. Still further south S. 14° E. and S. 12° E., and a lighter set S. 3° W.

250. A mile and a half to the northwest of Sutherland's Lake, along the road, due S. Slope N. Height, 650 feet.

251. On road going from Westchester station, I.C.Ry. to Acadia Mines and near border of map (sheet No. 4 N.W.), S. 14° E.

252. On Economy road near fourth brook crossed west of Thomson station, I.C.Ry., on Williamsdale road, N. 10° W. Height, 300 feet.

253. On road going west from Westchester station, I.C.Ry., on west side of brook, N. 6° E. Stoss side clearly S. Height, 310 feet.

254. North of Claremont Hill and between it and the I.C.Ry., fine striæ were observed on the roadside, N. 68° E. Stoss side W.

The ice producing these moved down the N.E. slope of Claremont Hill into the River Philip valley.

255. Two miles east of Oxford Junction on N. side of I.C.Ry. track, N. 12° W. Height, 125 feet.

256. North of Rodney, on northward slope, fine but distinct striæ, N. 12° W. and N. 3° E. Stoss side clearly S.

257. On Williamsdale road, half a mile from West Branch, N. 20° E., slope to N. Height, 225 feet.

258. Near Upper Maccan River on Five Islands road, S. 8° W. and S. 12° E., or the reverse. Height, 175 to 200 feet.

259. On road going south from Springhill and Parrsboro' Ry. along Harrison's brook S. 20° W. A mile from the railway, another exposure, S. 27° E. Height, 400.

260. On road which leaves Upper Maccan River road a mile and a quarter west of Mapleton bridge leading southward to a back settlement (South Brook settlement) about two miles up from river, N. 10° W. and N. 32° W. (may be on boulder). Stoss side distinctly to S. Height, 400 feet.

On another boulder near by N. 12° W.

261. On same road and just south of branch of South brook, on gray sandstone *in situ*, N. 6° W. and N. 8° E. Stoss side clearly S.

262. In West Brook settlement on second cross-road three miles south of Springhill and Parrsboro' Ry., S. 12° E., S. 22° E., and S. 18° W., or the reverse. Stoss side N. Height, 350 feet.

263. On cross-road leading north-westward from main road between Halfway Lake and Southampton, S. 12° E. (may be on boulder). Height, 120 feet.

264. On west side of River Hebert, about two miles above bridge, doubtful, S. 7° E. or N. 7° W. Stoss side apparently S.

Prince Edward Island.

265. A mile and a half south of North Cape, on the western coast, N. 52° E., N. 27° E. Height, 20 feet. In Prince Edward Island.

Four rods further south N. 57° E. and N. 47° E. Stoss side distinctly S.W. Height, 20 feet.

266. A quarter of a mile east of Lighthouse, North Cape, N. 53° E., N. 22° E. and N. 27° E. Height, 15 feet. The N. 53° E. set is the heaviest.

267. At Cape Kildare, on several exposures along the shore, S. 11° E., S. 13° E., S. 29° E., S. 23° E. and S. 18° E. Height, 10 feet.

268. On shore at Fifteen Point, S. 10° W. Height, 5 feet.

On road at Fifteen Point, S. 45° E. Height, 20 feet.

269. A quarter of a mile east of ferry over Ellis River, N. 69° E. and N. 50° E. Height, 4 feet.

271. At Linkletter's Point, in two places, under boulder-clay, S. 55° E. Stoss side apparently N.W.

272. At Clifton, east of cross-roads, N. 42° E. Height, 10 feet. On another exposure, N. 52° E., height, 110 feet; and a quarter of a mile west of Clifton, on ledge, N. 51° E. and N. 58° E. Height, 100 feet.

273. East of road on west side of Mill Creek, N. 22° E., N. 47° E., N. 45° E., N. 57° E, N. 54° E. and N. 65° E.

274. Just west of the end of the same road, N. 61° E., N. 47° E., N. 52° E. and N. 57° E. On a fresh surface near by N. 65° E. and N. 54° E.

275. At end of road at Mills Point, N. 52° E.

276. A quarter of a mile north of road end, at Mills Point, N. 52° E. and N. 37° E.; and a short distance farther north, N. 55° E., N. 51° E., N. 42 E. and N. 39° E.; and again on another exposure a few paces further north, N. 55° E., N. 49° E. and N. 51° E.

277. On old Prince Town road, north of Margate, N. 37° E. Height, 60 feet.

278. At New London Bay, one mile N. of Stanley bridge, N. 37° E.

279. At end of road N. of Beach Point, N. 37° E.

280. At breakwater, Prince Town, N. 11° E. and N. 22 E.

281. On old Prince Town road, one mile north of Punch Bowl, N. 42° E.; (doubtful). Height, 165 feet.

282. One mile west of railway wharf, Cape Traverse, S. 58° E. and S. 53° E.

283. North of Gordon Cove, S. 58° E.

284. Half a mile west of Cumberland Point, on a small exposure, N. 57° E. and N. 62° E. Just west of these, striæ, N. 57° E.

285. Immediately west of Cumberland Point, N. 53° E. and N. 63° E.

286. East of Carleton Point, S. 32° W., S. 27° W., S. 22° W. and S. 13° W. Height, 10 feet. And on other exposures near by, S. 22° W., S. 17° W. and S. 15° W.

It is probable these striæ have been produced by small local glaciers sliding down off the island into the depression now occupied by Northumberland Strait.

287. West of Cape Traverse, S. 53° E. Height, from 3 to 5 feet.

A few rods further west, S. 33° E., S. 38° E. and S. 48° E.

288. East of Westmoreland harbour, on south side of peninsula, S. 58° E. and S. 33° E.

Further east, at point, N. 57° E. or the reverse.

289. On east side of Sable River on road to Bonshaw (half a mile from river), N. 49° E., N. 57° E. Height, 170 feet. Slope W.

290. At cross-roads, Sable River, N. 57° E.

291. On New Bedeque road, three miles west of Hartsville, N. 47° E. Height, 300 feet.

292. Eighty rods east of junction of south-west road with New Bedeque road, N. 37° E. Slope W. Height, 160 feet.

293. West of intersection of County Line and New Bedeque road, N. 53° E. Slope W. Height, 200 feet.

293½. At intersection of above roads, an excellent exposure, N. 47, E., N. 52° E. Slope N.W. Height, 250 feet.

294. Half a mile west of the south end of Lot 30 road, N. 36° E. Slope S.E. Height, 190 feet.

295. On old Tryon road three miles south-west of North Wiltshire railway station, N. 27° E., or the reverse. Slope W. Height, 150 feet.

296. Fifty rods west of County Line, on cross-road, one mile north of Tryon, N. 57° E. Slope W. Height, 100 feet.

297. At end of road between Platt River and Bentick Cove, N. 47° E. and N. 57° E.

298. Near end of road north of Bentick Cove, N. 47° E.

Twenty rods further west, on several exposures, N. 27° E., N. 47° E., N. 52° E., N. 57° E.

299. A quarter of a mile east of ferry over Ellis River N. 50° E., N. 69° E.

300. On road at Fifteen Point, S. 45° E. Height, 20 feet.

And on shore at Fifteen Point, S 10° W.

PLATE III.—STRIÆ NEAR CAPE TORMENTINE, N.B.
(No. 9, List of striæ produced by floating ice.) View from east side.

301. At Cape Kildare, on several exposures along the shore, S. 11° E., S. 13° E., S. 18° E., S. 23° E. and S. 29° E.

303. On south-west side of St. Peter's Bay about three-quarters of a mile north-west of the railway station, N. 59° E.

304. Just west of first brook about two miles to west of St. Peter's railway station, N. 6° E. Stoss side, S.

Boulder-clay abundant on south side of St. Peter's Bay.

305. East of Souris on bank of first brook on shore, S. 14° E. Light and local.

Striæ supposed to have been produced by heavy floating ice.

Striæ produced by floating ice.

The floating ice which scored the rocks in many places along the coasts of the eastern provinces, as shown on page 104 M consisted mainly of heavy packs, or floes, and the striæ are due to their impinging force as they were driven against the land-border by winds, currents, tides, etc. The ice composing these packs does not seem to have been wholly such as may have been derived from the land ice of the region. Large portions have doubtless, come from the land ice of Newfoundland, Labrador and Greenland, borne hither by the arctic currents and the easterly winds which prevail in these latitudes. In the later stages of the glacial period, the southern part of the Gulf of St. Lawrence must have been largely choked up with these heavy ice-packs a great portion of the year. Coincident with this condition of the coast waters, the ice on the adjacent land-surface was melting and retiring, while a slow subsidence was going on. The rock scoring by local glaciers and that by floating ice may, therefore, have been to a large extent contemporaneous.

At Gaspé.

Commencing at Gaspé Basin, in the province of Quebec, we shall note the striæ produced by floating ice around the south-western embayment of the Gulf of St. Lawrence.

1. At Little Gaspé, N. 13° E., N. 23° E. and N. 28° E. Height, 75 feet.

2. South of Grand Grevé, N. 23° E.

These striæ have been produced by an irregularly-moving, jumping body, impinging heavily against the sloping coast-border. The marks vary in length from three or four inches to two or three feet, and are both fine and coarse, often a quarter of an inch deep, and apparently gouged out. They occur only on the east side of the widest part of Gaspé Basin, and have evidently been produced by packs of ice driven in from the Gulf of St. Lawrence by heavy winds, tides, etc., forcing ice-jams here.

At Baie des Chaleurs.

3. On the south-west side of the Baie des Chaleurs fine striæ, to all appearance produced by floating ice, occur. The best examples were observed near Belledune station, I.C.R. Half a mile north of the station at a height of about 100 feet, the following courses were seen: S. 39° W., S. 21° W., S. 19° W., S. 9° W., S. 5° W., S. 7° W., S. 2° W., S. 1° E., S. 3° E., S. 5° E., S. 8° E., S. 12° E., S. 13° E., S. 15° E., S. 16° E., S. 18° E., S. 19° E., S. 20° E., S. 21° E. and S. 23° E.

4. About half a mile south of the same station, S. 1° W., S. 5° E., S. 9° E., S. 10° E., S. 11° E., S. 15° E., S. 17° E., S. 21° E., S. 23° E., S. 27° E., S. 31° E., S. 29° E., S. 35° E., S. 38° E.

5. Going southward along I.C.Ry., one mile south of Fournier's brook, S. 5° W., S. 11° W., and on another ledge near, S. 18° E., S. 43° E. and S. 45° E.

6. Halfway between Fournier's brook and Elmtree River, on north side of a diorite boss, S. 9° W., S. 5° W., S. 3° E., S. 9° E., S. 11° E., and S. 13° E.

7. Still nearer Elmtree River another boss shows S. 27° W., S. 29° W., and S. 37° W., with a great number of fine criss-cross striæ.

8. Just north of Elmtree River, on bosses of diorite or diabase, S. 45° W., S. 37° W., S. 29° W., S. 25° W., S. 21° W., S. 17° W., S. 7° W. and S. 1° W.

The elevation of the rock surfaces where No. 3, 4, 5, 6, 7 and 8 sets occur, ranges from 100 feet down to 75 feet. The stoss side is everywhere distinctly to the N. The sides of the deep E. and W. grooves formed by the earlier land-ice are always stossed on the N.

The surface of the country on the south-west side of the Baie des Chaleurs, rises from the coast border with a gentle ascent, reaching an elevation of 500 or 600 feet at the sources of the rivers which drain the district. Against this sloping surface, floating ice, or ice-jams, seem to have impinged heavily in a direction at about right angles to the curved coast-line, along a zone of variable width, from 75 to 175 feet above the present sea-level. This part of the coast, being directly opposite the mouth of the bay, has received the full force and impact of the floating ice driven in from the Gulf of St. Lawrence by easterly storms. Hence the formation of these striæ along the zone mentioned.

At Cape Tormentine.

9. At Lane's quarry, near Cape Tormentine, striæ evidently produced by floating ice or ice-jams, also occur. One set seems to have been caused by ice shoved against, or over the Cape Tormentine peninsula, from Baie Verte, and shows the following courses:—N. 56° W., N. 44° W., N. 42° W., N. 38° W., N. 36° W., N. 32° W., N. 31° W., N. 30° W., N. 24° W., N. 18° W., N. 16° W., N. 12° W., and N. 2° W. The other set has apparently been formed by floating ice which came from

PLATE IV.—STRIÆ NEAR BAIE VERTE VILLAGE, N.B.
(No. 16, List of striæ produced by floating ice.) View from south-west side.

the north and north-west, and exhibits the following striæ:—S. 18° W. S. 13° W., S. 11° W., S. 10° W., S. 6° W., S. 4° W. and S. 3° W.

The N. 34° W. and S. 11° W. striæ or grooves are the heaviest. The scorings cover an exposed rock surface of 75 by 130 paces. The direction of the ice-movement in regard to both sets was determined by certain small crag-and-tail prominences on the nearly flat sandstone ledges. Height, 100 feet.

10. On the New Brunswick and Prince Edward Island railway, six miles and a quarter west of Cape Tormentine the two sets recorded under No. 9 again occur, viz. :—S. 5° W. and N. 37° W., and N. 32° W. Slope, S.E. Height, 135 feet.

These occur on a surface eight by four feet in extent. The western half is striated with the S. 5° W. course, some of the grooves being an inch deep; the eastern slope is covered with the N. 37° W. and N. 32° W., courses, which are light but well defined.

Thirty feet further east on an exposure ten by six feet, N. 37° W. and N. 32° W.; and on two other exposures near by the N. 15° W. course was seen.

11. On the Emigrant road about a mile and a half from Cape Tormentine, N. 32° W. and N. 42° W. Height, 50 feet.

In another place further west, N. 32° W.

12. At Bayfield, N. 2° W. and N. 12° W., or the reverse. Height, 15 feet.

Nearer Cape Jourimain Lighthouse, N. 12° W., or the reverse. Tide level.

13. On Emigrant road three miles east of Port Elgin, N. 27° W., N. 22° W., N. 16° W., N. 12° W. (deep), N. 7° W. and N. 2° W.; also S. 13° W. and S. 8° W. (both heavy). Striæ distinct. Height, 45 feet.

14. On Emigrant road, at third brook east of Port Elgin, S. 13° W. Height, 125 feet.

15. At Coburg quarry about one mile west of Baie Verte village, S. 38° W., S. 32° W., S. 28° W., S. 21° W., S. 18° W., S. 13° W., S. 10° W. Besides these are two courses, S. 8° E. and S. 4° E. or the reverse, and a third N. 68° E., or the reverse. Many broken, irregular, curved striæ occur and several curious markings. From the abundant crag-and-tail prominences, it appears the ice came from the north. Height, 55 feet. At Baie Verte.

16. About two miles from Baie Verte village, in an old quarry on the south-east side of the New Brunswick and P. E. Island railway, and about fifty rods distant from it, S. 43° W., S. 40° W., S. 38° W., S. 28° W., S. 23° W., S. 20° W., S. 18° W., S. 15° W., S. 13° W., S. 11° W., S. 3° W., and S. 12° E., S. 10° E., S. 4° E., S. 2° E. and S. In

addition to these N. 78° E., N. 68° E. and due E. sets occur, belonging doubtless to the older striation of the maximum extension of the ice. The other courses have apparently been caused by ice which came from the N.E., probably floating ice (ice-jams). The principal sets in these are the S. 43° W. and S. 18° W. striæ. The crag-and-tail projections are here also conspicuous. Height, 55 feet.

17. At east end of Chignecto marine railway, S. 2° E., S. 3° W., S. 13° W., S. 18° W., S. 23° W. and S. 28° W. These show stossing on the north side, but not clearly. The rock surface is covered with from 10 to 15 feet of boulder-clay, and the striæ have apparently been produced by ice impinging against it from the north, probably floating ice. Height, 40 feet or more.

18. On another ledge in the heavy cutting along the east end of the railway mentioned, and from half to three-quarters of a mile from the Tidnish dock, S. 3° W., and S. 18° W., with numerous minor and irregular courses.

Still further west in the same cutting S. 48° W., and S. 50° W.

These all appear to be the work of floating ice-jams.

At the latter exposure a set of striæ was observed with a course of S. 60° E., or the reverse, doubtless produced by land-ice.

19. At Cook's cutting, on the Chignecto marine railway, which is about the axis of the isthmus, and nearly equidistant from both ends of the line, S. 8° W., S. 18° W., S. 22° W., S. 23° W., S. 32° W., S. 38° W. and S. 46° W. The predominent sets are the S. 22° W., S. 28° W. and S. 32° W. ones. The striating agent evidently came from Northumberland Strait.

20. Half a mile further east on the south side of the railway track, S. 10° W., S. 18° W., S. 24° W., S. 30° W., S. 36° W. and S. 46° W. These appear to have been produced in a similar manner to the last.

The height of these ledges above mean tide level is 43 feet.

The manner in which the floating ice scored the rock surfaces on the Isthmus of Chignecto and the Cape Tormentine peninsula is referred to on pages 104-105 M.

In Shepody Bay.

21. In the vicinity of Germantown Lake, Albert county, in a valley trending parallel to the coast of Shepody Bay, a number of striæ occur which seem to have been produced by floating ice.

On the west side of Germantown Lake, south of Beaver Brook, S. 38° W. and S. 43° W. Height, 20 feet.

About 150 yards farther back on the same road, S. 6 °E., S. 18° W., S. 31° W., S. 38° W., S. 41° W. and S. 43° W. Height, 100 feet.

In another place near by on the same road, S. 28° W. and S. 38° W. Height, 125 feet.

Still further up the slope of the hill to the north-westward a large exposure exhibits, S. 3° W., S. 38° W., S. 40° W., S. 43° W. and S. 46° W. The S. 38° W. striæ are the best defined and most numerous. Several grooves can be traced from five to ten feet across the rock surface in straight parallel lines.

In another place near Beaver Brook, S. 43° W. Are all these floating ice striæ?

22. On the south side of Cocagne harbour, on a bank, half a mile below Cocagne village, S. 1° E., S. 6° E., S. 11° E., S. 12° E. and S. 9° W.

These may be due to floating ice, as they correspond with courses on P. E. Island and on the Isthmus of Chignecto. If produced otherwise it must have been by small local glaciers moving northward.

23. On Prince Edward Island striæ, evidently produced by floating ice jammed against the coast border, were found north of Cape Wolf, on the bank, at the shore, S. 9° E. Height, 5 feet. At P. E. Island.

24. At Cavendish, on the bank along the shore, S. 66° E. Height, 15 feet. Overlying the glaciated surface is a mass of boulder-clay upwards of ten feet thick without any intermixture of transported boulders, though they occur on the surface of the land near by.

25. A quarter of a mile south of Orby Head, S. 59° E. and S. 62° E.

26. One mile west of Cape Turner, S. 62° E.

27. On the south-west side of St. Peter's Bay, west of the railway station, S. 74° E.

None of these striæ occur on ledges more than from ten to twenty feet in height.

In the St. Lawrence valley, between Metis and Pointe Lévis, striæ, apparently produced by floating ice-masses moving up river, and in a few cases in the reverse direction, were noted. In St. Lawrence estuary.

At Bic, S. 54° W. Height, 125 feet.

At Trois Pistoles, north of Intercolonial railway station, S. 74° W.; west of station, S. 64° W. Height, 100 feet.

Just west of St. François station, I. C. Ry., bosses glaciated on both the east and west ends were observed.

Between St. Charles, I. C. Ry., and Pointe Lévis, striæ were found running S. 64° W. Stoss side to the east. Height, 145 feet.

Osar and Kames.

No moraines or drumlins are known to occur in the region specially referred to in this report, and it is doubtful whether there are even any of the structural boulder-clay deposits to which the name osar or eskers may properly be applied. Gravel ridges are met with along River Hebert, and Pugwash River, to the south of Thomson station, in Osar and kames. No moraines or drumlins.

Nova Scotia, and a ridge or series of ridges occurs east of Pictou. In New Brunswick short gravel ridges have been observed at the mouth of Renous River, or along the Southwest Miramichi above it, on the south of the Little Southwest Miramichi, opposite John Dennis's, twelve or thirteen miles from its mouth, also another about five miles west of Doaktown, stretching from the confluence of Big Hole and Meadow brooks to Bartholomew River, and a fourth at the source of Muzroll's Brook. Smaller sand and gravel ridges were observed elsewhere, and a number of the shallow lakelets of the Carboniferous area are bordered with kame-like ridges which have probably been formed by the expansion of the ice that covers them every winter.

Gravel ridges.

The Boar's Back.

The Boar's Back.

The most remarkable gravel ridge of the region is the one stretching along River Hebert, above referred to, called the 'Boar's Back.' It was long ago described by Sir J. W. Dawson,* and as measured by us is six miles and a half long, 130 to 135 feet in height above sea-level at the point of greatest altitude, and from ten feet in some places to twenty-five or thirty feet in others above the general level of the valley in which it lies. Although hitherto classified as a single ridge, it really consists of a series of ridges of greater or less length, arranged for the most part parallel, or approximately so, to the course of River Hebert, but a number are divergent and curving, and obviously without regular alignment. Some of the shorter ridges seem joined to, or rather have their ends abutting against, each other, or more frequently against a main dominant ridge, or series, along the summit of which the road runs, for there is really no main ridge. Sometimes it is one ridge that is the highest and widest, and again it is another abutting against the last and continuing for a greater or less distance. Not infrequently, however, there is a gap or hiatus between each ridge and the end of the next succeeding one, and lateral valleys on one or both sides intervening between it and the parallel ridge on one side or the other. In this way is the Boar's Back bunched up, so to speak, into a series of ridges in two or three places, within its whole extent, while between these bunched ridges, narrower and more linear ridges extend. At the lower or northern end of the Boar's Back, a certain stretch of it forms only one simple ridge. This part is low, narrow, and the material composing it is compact and resembles boulder-clay, or that of a moraine. For the next mile or two south of this, however, the ridge is irregular and in places entirely wanting. Occasionally short

Not a simple ridge.

*Acadian Geology, 2nd ed., page 82.

ridges run off from the main ridge nearly at right angles thereto, and sometimes they curve and inclose peat bogs.

Taking a general view of the ridges composing the Boar's Back, it is observed that those farthest away from River Hebert on the west side, are the highest, as if the summits of all those in a cross-section of the valley corresponded, roughly of course, to the former surface of a low valley before it became cut into ridges. But there are wide gaps and valleys between the ridges, and at intervals along the sides. Indeed, between the ends of several, we come across what is apparently a portion of the original land surface, flat and undisturbed, the material being sand and gravel belonging to the underlying sandstone. Nearly all the ridges are rounded or stossed at the south end, from which it is evident that the denuding agent moved against that end, *i. e.*, in the direction in which River Hebert flows at present.

The materials composing the series of ridges of which the Boar's Back consists are altogether local, belonging to the underlying Carboniferous rocks, only one or two small boulders apparently derived from the Cobequid series having been met with throughout the whole formation. They seem to be finer, perhaps, at the north end, but only in places, for there are also coarse deposits. In the southern part of the Boar's Back coarse beds seem to predominate. No rock outcrops were observed in the River Hebert valley.

How the Boar's Back was formed.

Viewing the facts broadly, the Boar's Back appears to be a series of ridges left from the denudation of a terrace or mass of stratified material which filled the valley to the level of the existing summits of the ridges or higher parts of the valley. But the material must have been worked over previously in some way by water-action to be thus rounded and stratified. Two modes of formation would seem to have prevailed, viz., the building up of some ridges, or what may be termed the constructive process, and the denudation of terraces and gravel banks, or the destructive process, the latter leaving remnants standing as ridges. As already stated, certain facts lead to the inference that the mode of formation, whether constructive or destructive, or both, proceeded not simultaneously, but consecutively, from the upper slope of the valley on either side towards the present river bed. For example, on the west side of River Hebert valley, as has been shown, there are curved and divergent ridges abutting against straight ridges. It would appear that the former must have been formed before the latter, for we cannot postulate any glacial, fluviatile or marine action which would shape them as they now stand on the supposition that they were produced simultaneously. The curving and cross ridges may, therefore, have been the earliest, and

may be due to eddying or cross currents, or perhaps to ice-action in the manner that banks are thrown up along the sides of rivers or on the borders of lakes. The straighter ridges were probably formed by more direct currents at a later date.

The Pugwash and Pictou Ridges, etc.

The ridge along the Pugwash River, is about a mile long and one hundred and fifty feet above sea-level. It follows the present stream closely, and consists of sand and gravel probably of fluviatile origin. This ridge seems to have been formed from the denudation of the valley drift.

Pictou ridge.

The Pictou ridge resembles the Boar's Back in some respects. As it lies beyond the region mapped it has not been examined except by way of comparison with the latter. It extends in a general north-and-south course for about two miles, and at the highest part is about one hundred and twenty-five feet above sea-level. Similarly to the Boar's Back it is not one continuous ridge, but two or more, and the materials composing it, while different from those of the latter, nevertheless, bear the same relation to the deposits of the district, as do those of the Boar's Back to the River Hebert valley beds. The Pictou kame contains boulders of granite, diorite, felsite, slate, conglomerate, etc. The peninsula to the east of the gravel ridge seems to have been a sort of "dumping ground" for débris, for it has numerous scattered mounds and short ridges of gravel, sand, etc., which are intermingled with greater or less numbers of transported boulders.

Gravel ridges in New Brunswick.

Turning to New Brunswick, we find gravel and sand ridges in several places in the valley of the Southwest Miramichi River. The most noteworthy of these is one occurring west of Doaktown, on the road running north-westward from that place, and at a distance of five miles from the Southwest Miramichi River. It extends in a nearly northerly course from the confluence of Big Hole and Meadow brooks to Bartholemew River, whether continuously or not we did not ascertain, the country being wooded; and it rises to a height of thirty or forty feet above the level of the surrounding country. This ridge is reported to extend down Barthelomew River for some distance, but was not traced by us.

A prominent ridge along the Southwest Miramichi above the mouth of the Renous River, and others found in the valley of the Little Southwest Miramichi, are evidently due to post-glacial denudation of the valley drift.

The question now arises :—Is there any general law governing the formation of these ridges and accumulations of gravel, sand and other drift materials besides those of ordinary denudation and shifting about of the deposits by fluviatile, lacustrine, marine and subaerial agencies? In the case of those ridges under discussion, a negative answer must I think, be given to this question. Each ridge, or series of ridges, seems to have been formed under the peculiar local conditions to which the materials composing it were subjected during the process of its development. Those met with in river-valleys, as shown, are doubtless due to the action of the rivers, those in lake basins to wave-action, the shove of the ice, etc., while those which may be classed as osar are the result of a complex series of causes which are yet only partially understood. As an illustration of how a ridge may be produced we may take the Boar's Back at River Hebert, which seems to have been formed of material first thrown down by Pleistocene glaciers and worked over by waters flowing out from the melting mass which occupied Halfway River valley. During the ensuing subsidence of the land, the sea invaded this valley and a strait existed by the pass through the Cobequids and along Halfway and Hebert River valleys, when a remodelling of these materials again took place. Subsequently as the land rose, a fresh-water lake seems to have occupied the basin in which Halfway Lake now lies, and its outflow by River Hebert valley again eroded and transported these gravels and sands. It is probably to the latter stage that we may refer the principal erosion which gave the ridges their present forms and contours. Since then the action of River Hebert in cutting down into the deposits occupying its valley, has doubtless produced other changes along its course and given to those ridges nearest the river their present pronounced features.

How these ridges have been produced.

The Boar's Back formed at several successive stages.

The kame at Pictou has not been studied as closely in its relation to the topographic and other features of the district in which it lies as the Boar's Back, but there seems to have been a greater amount of glacial and marine action experienced in its construction, and probably less lacustrine and fluviatile action.

The question of the origin of these ridges is one of great interest owing to their striking physiographic features, and its elucidation independent of pre-conceived theories, would aid in explaining a number of problems connected with the surface geology of the region.

Pleistocene Glaciers.

The theory of local glaciers upon the higher grounds and floating ice on the lower coastal districts proposed by me in 1885 and 1886* as

Theory of the glaciation of the region.

*Preliminary Report of the Surface Geology of New Brunswick, Geol. Surv. of Can., vol. I. (N.S.), 1885. Trans. Royal Soc. of Can., sec. IV., 1886, pp. 139-145.

a working hypothesis for the explanation of the Pleistocene glacial phenomena of New Brunswick and south-eastern Quebec, may now be considered, with certain exceptions and modifications, as established. It seems capable of explaining and co-ordinating a larger number of facts in the eastern maritime provinces of Canada than the hypothesis of great ice-sheets. There are, however, some anomalous questions regarding the dispersion of boulders on mountains and ridges that it does not account for satisfactorily, but all the divergent courses of striæ can be arranged and systematized under this method of interpretation better than by any other.

In the detailed work carried on by me during the past four years, chiefly in the coast districts of New Brunswick, and in parts of Nova Scotia and Prince Edward Island, a large body of data relating to the glaciation of the region has been collected. This will now be co-ordinated, and an attempt made to show the relation between the several local glaciers which occupied the coast region of the Acadian provinces of Canada during Pleistocene times, and also between these and the ice-mass or *nevé* of the north-eastern Appalachians.

The character of the floating or sea-borne ice which prevailed towards the close of the glacial period, and the courses of movement, or rather the direction in which the heavy packs, or ice-jams, impinged against the rock surfaces, will be shown. It may be remarked, that no striæ or ice-markings produced by the latter have been found above the highest shore-lines of the post-glacial upheaval; they are strictly confined to the lower slopes and marginal areas.

Local glaciers delimited.

In the present report it is proposed, first, to delimit the glaciers which occupied the country at the stage of the Pleistocene when they seem to have had their greatest extension. This will be an attempt not so much to show their superficial magnitude and thickness as to define their eastern and south-eastern margins, especially along the coast between Cape Gaspé and the International boundary at the St. Croix River in the Bay of Fundy.

General movements of the ice.

The ice which covered the Gaspé peninsula, and, indeed, all that part of the province of Quebec lying to the east of the Chaudière River and south of the St. Lawrence estuary, in the Pleistocene period, seems to have been local, although doubtless connected with the larger centre or centres of ice to the west. On the north side of the axis of the Notre Dame Range, it flowed into the St. Lawrence estuary, and here various courses occur showing that the movements were affected by the topographic features of the slope in a marked degree. The estuary must have been open during a part, if not the whole of the year, perhaps, similarly to Baffin's Bay and Davis Strait now,

into which the Greenland glaciers discharge. At what height the land stood here at the maximum extension of the ice is uncertain, no facts having yet been discovered in the valley of the lower St. Lawrence bearing directly on this question; but it was probably as high, if not higher, than at the present day. The striæ on this slope trend from N. 64° E. at Montmagny to due N. to N.W at Trois Pistoles, Bic, etc., and in other places to N. 50° W., indicating a wide range in the movements, due chiefly to the inequalities of the surface and to the fact that the glaciers followed the local valleys.

The border of the ice along the lower St. Lawrence during this stage of the Pleistocene cannot have been far beyond the present coast-line.

In the eastern part of the Gaspé peninsula, the ice flowed eastwardly, following the courses of the river-valleys there also. Striæ, evidently formed by land-ice, were found in Gaspé Basin with courses as follows:—On the west side, just south of Gaspé village, N. 70° E., N. 75° E., etc. Half a mile north of Cape Haldimand, N. 89° E., N. 83° E. and N. 75° E. On the east side, three miles south of the "Peninsula," so-called, on the road to Cape Gaspé, S. 87° E.; and between that and Grand Grevé, S. 63° E. and S. 65° E. Other striæ or glacial markings occur below Grand Grevé, but they have evidently been produced by floating ice and are described on page 79 M.

In eastern part of Gaspé peninsula.

The facts respecting the striæ in Gaspé Basin, when combined, show that a local glacier occupied its western end, drawing its supplies from the valleys of the York and Dartmouth rivers. It seems to have thinned out towards Cape Haldimand, the striæ showing a convergence from both sides towards the centre of the basin, and its margin must have lain somewhere in a line between Cape Haldimand and Little Gaspé. On the narrow peninsula terminating in Cape Gaspé, no ice-action is apparent, except the cross striæ produced by floating ice described on a previous page, the surface being covered with angular rock debris due to subærial disintegration. In Gaspé Basin and on the peninsula on the east side we have, therefore, the limit of the land-ice which moved eastwardly off the Gaspé peninsula.

Following the coast of the Gaspé peninsula southward and westward, till we reach Cape Maquereau, numerous striæ are found there, the average course of which is S. 44° E. and S. 45° E., showing that the ice was still local, and moved off the slopes into the open Gulf of St. Lawrence, or mouth of the Baie des Chaleurs, in a direction at right angles to the coast-line. The margin of the ice was probably nearly coterminous with the then existing coast, which appears to have been slightly higher there also than at present.

At Cape Maquereau, Baie des Chaleurs.

The Baie des Chaleurs Glacier.

The Baie des Chaleurs glacier.

The western end of the Baie des Chaleurs depression and the valleys of the Cascapedia, Nouvelle, Metapedia, Restigouche, etc., tributary to it, were occupied by a glacier in the early part of the Pleistocene. The terminus of this glacier was about the 100-foot contour line below the present level of the bay, that is, nearly in a line across from the mouth of the Bonaventure River, Quebec, to Belledune Point, New Brunswick. East of this line on both sides of the Baie des Chaleurs, the striæ indicate ice-movements more directly into the depression of the bay.

To this ice-mass I shall give the name of the Baie des Chaleurs glacier.* Its source was in the Notre Dame Mountains and principally in the drainage basin of the Restigouche River; but it also drew supplies from the Scaumenac, Nouvelle and Cascapedia valleys. The extreme length of the Baie des Chaleurs glacier was not less than 120 miles, but it was doubtless connected with other glaciers or sheets of ice, to the north, west and south, and with the central north-east Appalachian *nevé*. Its width in the Baie des Chaleurs valley, where it was greatest, was 35 to 40 miles, and its extreme thickness was probably 900 to 1,000 feet.

The Northumberland Glacier.

The Northumberland glacier.

Bordering the Baie des Chaleurs glacier on the south-east, along the divide between the drainage basin of the Baie des Chaleurs and that of the Miramichi rivers, and probably coalescent with it, there existed a large glacier in the early Pleistocene to which the above name is applied. Its north-western connection or *nevé* has not yet been traced; but the glacier is known to have descended in a general eastward to north-eastward direction from the region about the headwaters of the Miramichi rivers into the Gulf of St. Lawrence. The southern limit was near the watershed between the Miramichi and other rivers flowing into the Strait of Northumberland and the St. John waters, and extended along by Indian or Lutz Mountain, the watershed of the Isthmus of Chignecto, the northern base of Mount Pleasant, Cumberland county, Nova Scotia, Head of Tatamagouche, Hardwood Hill, west of Pictou, etc. From the mainland of New Brunswick it extended eastward across what is now the Strait of Northumberland and overrode a portion, if not the whole of Prince

* Can. Naturalist, Montreal, vol. X., 1881; The Glacial Phenomena of the Baie des Chaleurs Region.

Edward Island. Boulders and drift from the mainland of New Brunswick occur intermixed in the boulder-clay in the western part of this island, and sparingly as far east as the higher grounds in the central part. The table of striæ and the maps accompanying this report show different sets of striæ, but only those trending eastward have been produced by the Northumberland glacier.

Magdalen Islands non-glaciated.

The Magdalen Islands are non-glaciated, and it would seem that the mainland ice has gone no further than the eastern and north-eastern border of Prince Edward Island, the south-eastern part having, apparently, been glaciated by ice which accumulated on the island itself, and, therefore, containing no débris from the mainland intermixed with the boulder-clay. This fact accounts also for the scanty occurrence, or absence of transported or foreign boulders on the higher grounds, although the striæ show eastward movement there. The other courses of striæ will be discussed later on.

The south-eastern terminus of the Northumberland glacier, therefore, would seem to have been along a line near the coast border from Miscou or Shippegan Island to the mouth of the Miramichi River, crossing the latter probably outside of Portage Island; thence it curved round towards North Cape, Prince Edward Island, and followed the north-east side of the island probably to East Cape. In the depression occupied by Northumberland Strait, it does not seem to have gone farther eastward than Pictou harbour.

On many portions of the area covered by the Northumberland glacier, the ice has been thin and light and had little eroding power, large sheets of rotted rock occurring undisturbed on the mainland as well as on Prince Edward Island.

The depression occupied by the waters of the Strait of Northumberland, appears to have influenced the ice-flow wherever the present depth of the sea does not exceed 100 to 110 feet. Beyond that, the striæ indicate that the ice-movements were independent of the general eastward trend of the Northumberland glacier; hence it is assumed that the latter terminated at or near the 100-foot contour line below sea-level.

It is probable that the source of the Northumberland glacier was in the higher grounds of central New Brunswick. The St. John and St. Lawrence waters interlace in the north-western part of the province, and the *nevé*-ground of this glacier must have been to the north of Lake Nictor. Further investigation is, however, required to settle this point.

The Saint John Valley Glacier.

The St. John Valley glacier.

Passing from the watershed of the Gulf of St. Lawrence to that of the Bay of Fundy, a marked difference is apparent in the character of

the glaciation and of the drift deposits. The general trend of the ice-movement on this slope is south to east-south-east, varying according to the direction of the great valley of the St. John River and the general slopes of the surface. Near the mouth of that river, courses of striæ bearing west of south occur, belonging apparently to a stage when the ice had passed its greatest development and was on the wane.

Area of the St. John Valley glacier.

The St. John Valley glacier was the largest of the sheets occupying Canadian territory south of the St. Lawrence Valley. Its source, or *nevé*-ground, was in the highlands of the northern part of the state of Maine, in the Eastern Townships of the province of Quebec and in north-western New Brunswick. Large tributary glaciers joined it from the valleys of the several affluents. On the north-east side the margin was probably in contact with the Northumberland glacier along a great part of the watershed separating them; on the west it merged into the ice which covered the state of Maine, and may, indeed, have been partially, if not wholly confluent with it, though pursuing, for the most part, a more eastward course. Whether confluent or not, the St. John Valley glacier seems to have been thicker and more massive as we proceed from east to west. This is, no doubt, the result of the more favourable conditions for its development. Proximity to the evaporating surface of the Atlantic, and, of course, a greater amount of precipitation and a higher and better condensing surface, were, doubtless, the predisposing causes for the greater accumulation of Pleistocene ice in the St. John Valley and on the Bay of Fundy coast, as well as westward. The front of the St. John Valley glacier is difficult to trace. It is doubtful whether this glacier surmounted and overrode the whole of that part of the crystalline plateau lying east of the mouth of the Saint John River. It certainly did not do so with the relative levels of this crystalline plateau and the Carboniferous area to the north of it the same as at the present day. There are some facts at hand which tend to show that the latter must have been higher, relatively, when the St. John Valley glacier discharged into the Bay of Fundy. But this glacier, or system of glaciers, became much broken up in its passage through the hills bordering that body of water, as it proved by the divergent courses of striæ along the coast.

Causes of its greater thickness.

Just where the margin of the ice which properly belonged to the St. John Valley glacier lay to the west, or whether it was coalescent with the ice occupying the territory of the State of Maine, it is not possible to determine with the limited amount of data at hand. Further investigations about to be undertaken in western New Brunswick may elucidate this question.

In regard to the glaciation of the plateau along the Bay of Fundy to the east of St. John harbour, if not due to ice overriding it from the St. John Valley and from Grand and Washadamoak Lake basins, etc., then it must be that local ice-masses accumulated upon it which flowed out towards the open waters of the Bay of Fundy. At St. John harbour and west of it, however, the ice margin seems to have extended beyond the present coast-line, apparently stretching out farther and farther as we proceed westwards towards the International boundary. This fact is in accordance with the view that the meteorological and physicial conditions necessary for the production of glaciers were more favourable on the Bay of Fundy coast and westward than in the Gulf of St. Lawrence.

The Chignecto Glacier.

On the Isthmus of Chignecto and in the two arms of Chignecto Bay, and probably extending as far to the south-west as Cape Enragé on the one hand and the mouth of Apple River on the other, there existed a local glacier in the early Pleistocene, the general movement of which was south-westward into the open waters of the Bay of Fundy. Striæ produced by this glacier are found near Shepody Mountain Albert county, New Brunswick, from 500 to 600 feet or more above the present sea-level, and on the opposite shore, in the vicinity of Sand and Apple rivers, from 350 to 400 feet high. In the central parts of the Isthmus of Chignecto, viz., at Westcock, Dorchester Cape and north of Folly Point, striæ, to all appearances produced by this body of ice, also occur at elevations of 300 to 400 feet. The striation is distinct and well defined, and leaves no doubt that it has been caused by a pretty large body of ice flowing in the direction indicated. The Chignecto glacier.

In seeking the source of the Chignecto glacier, or rather the height-of-land which gave it momentum, great difficulties were encountered. At first an attempt was made to explain the glaciation by the action of floating ice; but this agency, while competent to account for certain striæ produced at a later stage of the glacial period in this region, did not seem capable of explaining certain phenomena pertaining to the Chignecto glacier. For example, in Albert county the striæ attributable to the action of this glacier occur on both northward and southward sloping declivities, and cross narrow valleys, such as that of Demoiselle Creek, obliquely. They are met with at altitudes varying from sea-level up to 500 and 600 feet, and are parallel on the higher as well as on the lower slopes on opposite sides of Chignecto Bay. These and other facts which might be cited evinee the action of land ice only. At the

same time it is not denied that a considerable part of the striation of of the lower grounds on both sides of Chignecto Bay as well as on the isthmus is due to floating ice—in the latter district, indeed, it was chiefly produced by this agency, at a subsequent stage of the glacial period. But on the higher levels, the glaciation seems to be entirely due to land ice.

It has been stated on page 26 M, that the height of the Isthmus of Chignecto, near Northumberland Strait, does not exceed seventy-five to one hundred feet. Some hills and undulations rise to one hundred and twenty-five to one hundred and fifty feet, but on the other hand a large part of the isthmus is low and flat, and not more than fifty to sixty feet high. The elevation of the axis exceeds this but very little, except upon the ridges lying between Memramcook and Sackville, portions of which rise above the 200-foot contour. How then did ice flow south-westwardly off the isthmus into Chignecto Bay, and override the ridges around the head of it, while portions of this ice apparently rose two hundred to three hundred feet above the level of its source? This was one of the problems presented to us in studying the glaciation of this region. To satisfy ourselves regarding the source or *nevé*-ground of the Chignecto glacier, a thorough examination of the isthmus was made, and our investigations extended to Prince Edward Island, to the eastern extremity of the Gaspé peninsula and to the Magdalen Islands. If the gathering-ground of this glacier had been beyond the Isthmus of Chignecto, we concluded it would have striated the higher grounds of the eastern extremity of Gaspé and of Prince Edward Island in its passage southward. No north-and-south, or north-east and south-west striation was found on the higher portions of Prince Edward Island or at Gaspé, however, and the Magdalen Islands were discovered to be unglaciated. On the south-west slope of Prince Edward Island, facing the Isthmus of Chignecto, there are a few scattered striæ, but they seem due to local ice sliding off the island at a later stage. Finding no solution of the problem in this way, we then had to re-investigate the north-eastern side of the Isthmus of Chignecto anew. Numerous striæ are found here, as detailed on the map, but they all indicate the action of floating rather than land ice. It is possible some of the older sets may have been produced by the latter agency, but the rocks are soft sandstone, easily eroded, and these striæ may have been mostly obliterated. With all the data available, therefore, we have been forced to the conclusion that the Chignecto glacier is, after all, one which developed on the Isthmus of Chignecto, and in the depression between that and Prince Edward Island, and as inferred on page 27 M the relative levels of the axis and of the north-eastern part

Gathering ground of the Chignecto glacier.

of the isthmus as well as the bottom of Northumberland Strait must have been higher than at present, and the south-western part and the coast borders of Chignecto Bay lower.

The Chignecto glacier was doubtless a product, partially at least, of the evaporation from the open waters of the Bay of Fundy, and its condensation in this particular locality. This probably caused the formation of such a thick mass of ice under such exceptional circumstances; for, to the south-west of Cape Maringouin it can not have been less than five hundred or six hundred feet thick. But its superficial dimensions were limited, its length being probably not more than forty-five to fifty miles, and its extreme width eighteen to twenty miles.

Peculiar development of Chignecto glacier.

The origin and development of the Chignecto glacier under such peculiar local conditions, are no doubt also partly owing to the fact that the Northumberland Strait to the north-east was, at that time, choked up by the Northumberland glacier, and thus the former was forced to seek outlet to the open waters of the Bay of Fundy. Indeed, it is not improbable that a portion of the Northumberland glacier may have swung round and passed out over the Isthmus of Chignecto towards the Bay of Fundy, as suggested to me by Dr. G. M. Dawson, thus forming the source or head of the Chignecto glacier, though few, if any striæ have been found indicating such a swerving movement, which would really mean a change from a due easterly course to one nearly south-west. On any view of the question therefore, difficulties are met with, and no fully satisfactory solution of the problem of the glaciation of the Isthmus of Chignecto has yet been found.

Glaciation of Nova Scotia.

The glaciation of Nova Scotia.

The facts adduced in regard to New Brunswick glaciers in the early Pleistocene, appear to demonstrate that no ice reached the peninsula of Nova Scotia from the mainland, except those portions of the Northumberland and Chignecto glaciers which impinged on the coasts of Cumberland county, the former in the Strait of Northumberland, the latter in Cumberland Basin. The depression of the Bay of Fundy was not crossed by land ice from southern New Brunswick, nor did ice move across the Isthmus of Chignecto in any direction, but as indicated. Neither has Nova Scotia been glaciated by extra-peninsular ice from the north or north-east, except, perhaps, by some floating ice on the coastal areas. Whatever glaciation it received from land ice, and some districts have been very heavily striated, has been wholly from that which accumulated upon the surface of the country itself.

Local and divergent striæ.

In the portion of that province included in the map, the striation is extremely local and divergent. Ice gathered on the summits of the Cobequids and also on some other elevations such as Mount Pleasant, Springhill, etc., and moved thence in both directions, *i.e.*, northward and southward. Some of the striæ on the slope between the Cobequids and Northumberland Strait may belong to a later date than that of the Northumberland glacier. On the south side of the Cobequids, a pretty large local glacier moved westward from Minas Basin into the Bay of Fundy. Striæ showing the movement of the latter occur at Spencer's Island, S. 67° W. and S. 70° W., etc. To the east, however, a local glacier seems to have flowed off the southern slope of the Cobequid Mountains, crossing the eastern part of Cobequid Bay, and thence passing over the low country traversed by the Intercolonial railway, discharged into the Atlantic in the vicinity of Halifax. Striæ with north-west stossing were observed near Shubenacadie, and thence to the Atlantic coast, showing this ice-movement very clearly.

To the south-west and south of the Basin of Minas, the ice which accumulated on the peninsula moved outwards towards its periphery north-westward, westward, southward and south-eastward. From the South Mountain it crossed the Annapolis Valley, overriding the North Mountain, and passing thence into the Bay of Fundy. Striæ proving this were found at Bridgetown, Annapolis, Digby, Head of St. Mary's Bay, etc. On the South Mountain, at the first-mentioned place the following courses occur:—N. 32° W., N. 47° W., N. 54° W., N. 62° W. and N. 70° W.; on the North Mountain here, N. 22° W., N. 40° W., N. 47° W. and N. 52° W., and near the coast of the Bay of Fundy, N. 57° W. and N. 72° W. The North Mountain is here upwards of one hundred feet higher than the South Mountain from which the ice came, yet granite boulders from the latter, of all sizes up to ten feet in diameter, are strewn over the slopes of the North Mountain down to the shore of the Bay of Fundy.

Glaciation of North Mountain.

At Annapolis, striæ occur on the North Mountain trending N. 32° W., N. 34° W., N. 42° W., etc. The stoss side is to the south-east and the surface is everywhere strewn with granite boulders from the South Mountain.

On the North Mountain at Digby, the striæ run N. 42° W., N. 52° W., N. 56° W. and N. 68° W., the two latter courses being near the coast. Granite boulders from the South Mountain are also abundant here.

At the head of St. Mary's Bay the North Mountain presents a great stoss side to the south-east, the courses of striæ there being N. 70° W., N. 74° W., etc. These show a swerving of the ice-movement in

the direction of the deeper parts of St. Mary's Bay. The glaciation along the North Mountain has apparently been heavy, extensive ledges and bosses being deeply grooved and ice-worn.

Near Yarmouth, striæ occur with a course of S. 3° E., showing ice-movement mostly in the direction of the estuaries.

Local ice the glaciating agent.

It will be seen that the above courses taken together with those noted by other observers on the south-east coast, clearly point to local ice as having been the glaciating agent in the peninsula of Nova Scotia. The ice on the south-east slope has probably been heavier than on the north-west side during the stage of its maximum extension. Facing the Atlantic ocean, this slope, similarly to the New Brunswick slope of the Bay of Fundy and the New England coast region to the west, was very well situated for the nourishment of glaciers. The free discharge afforded the ice into the sea along its margin, enabled it to erode the rocks over which it passed to a much greater extent than in the interior. This erosion is exhibited in the deep grooves and rounded bosses on the south-east and north-west coasts of Nova Scotia.

Eastern and South-eastern Limits of the New Brunswick Glaciers.

Limits of the glaciers above described.

The limits of the several local glaciers just described, are known approximately at least, and are delineated on the accompanying sketch-map. What was probably the margin of the ice, was located on the east side of Gaspé Basin, the point of land terminating in Cape Gaspé being unglaciated. In the Baie des Chaleurs basin, there is evidence that the local glacier which occupied it did not extend farther to the east than Bonaventure River and Belledune Point, smaller local sheets debouching into the depression from both sides of the bay to the east of that. The ice extended along the peninsula between the Baie des Chaleurs and Northumberland Strait as far as Caraquette, and perhaps partly overrode Shippegan Island; but the northern part of Shippegan and all Miscou Island have not furnished any evidences of glaciation. Just where the ice-border lay in Miramichi Bay, is problematical; it may have been along or near the hundred-foot contour below sea-level, swerving outside of North Cape, Prince Edward Island, and, perhaps, following the north-east coast of that island to East Cape. Thence the limit of the ice doubled and ran towards Pictou harbour, Nova Scotia. The southern margin of the New Brunswick ice coincided with that of the Northumberland glacier, already described, as far as the Isthmus of Chignecto. If we include the Chignecto glacier among the New Brunswick ice-sheets, the border would extend round by Amherst and the mouth of the Maccan River, thence

following the summit of the low ridge to the south-east of Cumberland Basin as far as Apple River, and, perhaps, to the northern base of the Cobequid Mountains. The probable position of the front of the Chignecto glacier was outlined on page 93 M. On the New Brunswick side of the Bay of Fundy, the ice-border seems to have lain pretty close to the coast west of Cape Enragé, as far as St. John harbour. Here and to the westward it evidently extended out beyond the present land, overriding the islands adjacent thereto. Its extension seaward probably increased the farther westward we proceed until reaching Grand Manan, which the mainland ice appears to have surmounted and glaciated.

Around the peninsula of Nova Scotia, the margin of the land ice was not definitely traced, but it probably extended very little beyond the line of the present coast.

Absence of Terminal Moraines.

Absence of terminal moraines.

No terminal moraines have been observed along the east and south-east margin of the glaciated area described in these pages. Moraines may have existed and have since been denuded and entirely washed away by the action of the sea, during the post-glacial submergence of the coast border, but this is extremely doubtful. The mode of occurrence of the boulder-clay and the distribution of the transported boulders do not afford evidence of any linear arrangement of deposits either as terminal or lateral moraines in the region, except, perhaps, in southern New Brunswick, on the watershed between the St. John Valley and the Bay of Fundy, where small local glaciers left a few irregular ridges at the final retirement of the ice, which may be classed as such. There is a greater or less sporadic distribution of glacial material, but it is very seldom heaped up in ridges or mounds.

Without entering into the vexed question of the mode of carriage of the drift by glaciers, a few observations may be offered regarding glacial transportation in the particular area under review.

Mode of distribution of the drift in eastern New Brunswick.

The mode of distribution of the drift is largely dependent upon the topographic features. In hill or mountain districts which border valleys or plains, glaciers receive an impetus from the steeper gradients, enabling them to erode and often sweep off the débris down to the rock surface, exhibiting the striation and polishing. In the valley bottoms this débris is thrown down and lies until again eroded by the ice, or by rivers or streams. In this case, whatever material the ice carries off one place it deposits in another near by, similarly to a river. Often at the base of declivities, on the lee side, masses of drift have thus

been deposited; but occasionally in districts of hilly or irregular surface, the boulder-clay occurs as mounds or lenticular masses on the more level tracts, or again it may be massed against hills on the stoss side; being in all these instances generally well mixed with transported and glaciated boulders and pebbles. In localities glaciated in this manner, which are quite common in New Brunswick and Nova Scotia, there will be found rock surfaces of greater or less area laid bare and highly striated and polished, the material which originally covered them having been wholly or partially removed by the ice. These may be called ice-swept surfaces, in contradistinction to flat surface, over which the ice has distributed the boulder-clay more evenly and through which rock surfaces seldom appear. The latter condition is characteristic of the Carboniferous area of New Brunswick. Here glacier motion has been comparatively sluggish, and the greater portion of the boulder-clay is more local in character. In many parts of this area, the rotted rock lies still undisturbed, and the boulder-clay is often thick and in wide, regularly-distributed sheets. Successive additions of the latter have been deposited here and there also, and the transported boulders are more numerous, as a rule, in the upper part of the deposits, and especially on the surface, the latter feature, however, being doubtless partly a result of subsequent denudation.

From the evidence at hand, it appears that the slopes of the higher grounds of New Brunswick and Nova Scotia have been as a rule more heavily glaciated than the lower coastal districts around the south-western embayment of the Gulf of St. Lawrence—a heavily glaciated district usually presenting many bare ice-swept rock surfaces, while one across which ice has moved sluggishly is deeply masked by superficial deposits. This has been the case especially on the lower grounds of New Brunswick, Nova Scotia and Prince Edward Island, occupied by the Northumberland glacier.

This sluggish motion and thinning out of the ice near the margins of the Baie des Chaleurs, Northumberland and St. John Valley glaciers, together with the fact that they terminated in the sea in many places, has been unfavourable to the formation of terminal moraines; hence the absence of these deposits in this region. Why there are no terminal moraines in the region.

Relations of the Local Glaciers to the Appalachian Nevé.

The glaciers of eastern Canada, just described, evidently had their sources and *nevé*-grounds beyond the boundaries of New Brunswick, in the Notre Dame or Green Mountains in northern New England and Relations of the glaciers described to the Appalachian system.

the province of Quebec. These grounds have not yet been systematically explored. But they had also local gathering grounds on the watersheds or divides between each glacier, especially on that between the drainage basin of the St. John River and of those rivers flowing into the Strait of Northumberland and Gulf of St. Lawrence, which seems to have been an ice-shed during the whole glacial period. The Northumberland glacier may have had its *nevé* entirely within New Brunswick.

The ice which occupied the region lying to the south of the St. Lawrence Valley, in the early stage of the glacial period, flowed from the higher parts of the Notre Dame or north-east Appalachian Range in widely divergent courses and to different points of the compass, the movements being largely dependent on the topography and relation to the central mass or *nevé*. In the province of Quebec, the ice followed, for the most part, the existing drainage channels, northward, eastward and south-eastward a considerable body of ice passing from the district known as the "Eastern Townships" into the valley of the upper St. John River. In northern New Brunswick, the general trend of movement was from west to east or to north-east, the Baie des Chaleurs glacier flowing nearly due east and the Northumberland glacier eastward to north-eastward. In the southern part of the province, the ice partook of a more southerly course, the St. John Valley glacier moving nearly south-eastward. Further west the courses swerve more and more to the south, the ice having thus a more or less radial movement from the higher portions of northern New England and Quebec. Whether the ice-mass consisted of one confluent sheet, similar to the Greenland sheet of the present day, or of local glaciers, is a question which can only be solved by further detailed observations and mapping of the striæ. That it was thick and massive on the more elevated grounds is highly probable. Indeed, from a comparison of the physiographical and meteorological conditions which prevail in those parts of the world where glaciers now occur, with such as must have existed in the north-east Appalachian region in Pleistocene times, we may infer that it was a very favourable gathering-ground for ice. Three things essential to the production of heavy glaciers seems to have been present here, viz.:—proximity to a large evaporating surface, heavy precipitation, and an area of considerable altitude, serving as a condensing surface. The height of this region was probably greater in the early Pleistocene than at present. Hence a large ice-sheet, or several ice-sheets, must have been devel oped here, which in thickness, though not in superficial extent, was perhaps second to no other in North America.

Glacial conditions of the region in the Pleistocene.

As having some bearing on the question of the evaporation from the Atlantic ocean during the glacial period, or, perhaps, during its later stages, reference may be made to the occurrence of marine shells in the boulder-clay and drumlins near Boston collected by Upham, Dodge and others. These shells were found to be closely similar to species now living in the waters adjacent to the New England coast. May this fact not be taken as showing, that at the time they lived in these waters, the temperature of the ocean along the New England shores cannot have been very far different from that now prevailing? If so, then the evaporation from its surface must also have been as great as at the present day.

Temperature of the New England coast waters in Pleistocene times.

Departure of the Pleistocene Ice.

Whatever changes in the meteorological conditions occurred between the earlier stage of the Pleistocene period, or period of maximum ice accumulation, and that about to be discussed, have left no traces in the phenomena of the region; nevertheless, it is certain that important changes did take place both as regards climate and elevation of the land.

As shown on page 33 M it would seem that soon after the maximum of ice accumulation was reached in the eastern provinces of Canada, a subsidence of the region commenced, which so far as the evidence goes, was continuous not only till the close of the ice age, but for some time afterwards, that is, until the Leda clay was deposited. The subsidence, as stated, was more or less differential, evidence of which is afforded in the divergent ice movements at the breaking up and dissolution of the Northumberland and Chignecto glaciers. The arctic climate of the region during this stage, is also shown by the marine shells found in the boulder-clay at St. John, New Brunswick. The local glaciers which occupied the slopes of the coast region, and the floating ice-packs or ice-jams impinging against these slopes during the closing stages of the ice epoch, when the land stood lower than at present, have scored the rock surfaces, leaving records of their existence and of the attitude of the land at that stage.

Departure of the Pleistocene ice.

Brief descriptions of the striæ produced by local land ice and by floating ice, and of other phenomena pertaining to this the closing or melting stage of the glacial period will now be given, and the different localities where such phenomena were observed noted.

Local Glaciers During the Closing Stage of the Ice Age.

On the south side of the Baie des Chaleurs, striæ, evidently produced by local glaciers during the retirement of the main Baie des

Local glaciers of this stage of the ice age.

Chaleurs glacier, were found at Dundee settlement, south of Dalhousie Junction, in Lorne and Sunnyside settlement in the rear of Jacquet River, in Ste. Louise and Middle River settlement near Bathurst, etc. In these places the ice referred to has slid down more directly into the Baie des Chaleurs depression, uninfluenced by the main Baie des Chaleurs glacier described on page 90 M.

In the Baie des Chaleurs region.

The striæ produced by these glaciers are found upon the slopes at heights varying from 150 to 500 and 600 feet above sea-level, and the ice producing them was probably contemporaneous with the floating ice-packs or jams which impinged against the coast as shown on page 79 M, at the closing stage of the ice age. These glaciers and ice-jams existed and performed their work previous to the deposition of the Leda clay and Saxicava sands, otherwise these beds would have been disturbed and eroded, if not entirely destroyed by them. In several places around the southern embayment of the Gulf of St. Lawrence, the marine deposits referred to are found resting upon rock surfaces which must have been glaciated by local glaciers or floating ice of the character described, showing that they have been deposited at a subsequent stage.

In the region to the west of Northumberland Strait.

The area which was occupied by the Northumberland glacier, shows some remarkable traces of local ice-movements at the retirement or breaking up of the larger sheet. As has been shown on a former page, the general trend of the ice-movement in the early part of the glacial period here was nearly due east. But we find that in the later or melting period, the glaciers of the higher grounds had swerved round and took nearly a northward course. Intermediate courses were observed at Renous River, Rogersville station, and along the Intercolonial railway to the south, especially at Harcourt, Coal Branch, etc., which tend to show that this swerving of the ice-movements may have been gradual and probably was coincident with a differential change of level of the district. Correlating all the facts, it would appear that as the ice began to diminish in thickness, the axis or watershed between the St. John waters and those falling into the Strait of Northumberland did not subside, and perhaps, was not denuded, to the same extent, as the coast border, and coincident with the decreasing thickness of the ice and this change of level, the movements of the small local glaciers had become entirely governed by the slopes of the country before their final disappearance.

Further, these facts indicate that there was no withdrawal of the ice from this region during a supposed interglacial epoch ; on the contrary, that it continued here throughout the whole period of the deposition of boulder-clay without recession.

On the borders of Shepody Bay.

In the northern and eastern parts of Albert county, and also locally on some of the higher slopes of the ridges traversing the Isthmus of Chignecto, evidences of local glaciers occur whose action took place after the Chignecto glacier had dwindled down and subsidence of the district had set in. Striæ showing local ice-movement towards the lower parts of the isthmus were also observed at Amherst and Fenwick in Cumberland county, Nova Scotia. Farther east, on the slope between the Cobequid Mountains and Northumberland Strait, striæ are met with in numerous places indicating local ice action by northward-moving sheets down nearly to the present sea-level. Local glaciers appear also to have occupied the summits and slopes of the Cobequids and the drainage basin of the Maccan and Hebert rivers, flowing in different directions as influenced by the topographic features.

From Shepody to Passamaquoddy Bay.

Along the Bay of Fundy coast, from Shepody Bay to Passamaquoddy Bay, many courses of striæ were observed which can only be explained on the supposition that they were produced by local glaciers at the closing stage of the ice period. These were noted at Quaco, West Beach, Mispec, St. John, Musquash, Letite and on the West Isles, and exhibit in some of these localities, at least, very divergent striation dependent largely upon the local contours of the surface. The most remarkable of these local glaciers seem to have existed at the mouth of the St. John River. On the west side of the harbour, striæ occur trending to different points of the compass between S. 2° W. and S. 65° E.; on the east side they trend from S. 15° W. to S. 55° W. Convergent movements are, therefore, shown in these sets, varying from S. 65° E. on the west side of the harbour to S. 55° W. on the east side. While it must be admitted that some of these convergent striæ may be due to undertows during the maximum extension of the St. John Valley glacier, the greater number have probably been formed by ice discharging in the harbour as local glaciers. It must be added, however, that in this locality, we have, so far, been unable to differentiate the striæ produced at the period of maximum glaciation from those produced at the later or melting stage of the ice. That local glaciers existed here, however, and extended into the open waters of the Bay of Fundy at the retirement of the Pleistocene ice, is sufficiently proved.*

Reviewing all the facts, it is evident that the theory of local glaciers advancing and retiring, during the later stage of the glacial period, with the coast 100 feet or more lower than at present, will serve to explain all the phenomena. The climatic conditions seem to have been

*Bulletin Geol. Soc. of America, vol. IV., pp. 361-370.

at least subarctic; but an amelioration had set in apparently coincident with the progressive subsidence of the coast in the different parts of this maritime region.

On the P. E. Island coast.

On Prince Edward Island, local glaciers and floating ice were doubtless predominant during the period of subsidence and melting of the ice. The former have left evidences of their existence at New London and to the west and south-west of Richmond Bay; also on the south-west coast of the island at Fifteen Point, Carleton Point, De Sable, etc. From the position of the striæ produced by floating ice with respect to sea-level, the land cannot have been more than from 50 to 100 feet lower than at present at that time.

No deformation of the surface between the later and earlier stages of the glacial period was traceable at St. John, New Brunswick, or on Prince Edward Island, such as that described as occurring in the central Carboniferous area of New Brunswick; but the facts are from limited areas only, and, even if there had been deformation, this could scarcely be discerned.

Floating or Sea-borne Ice.

Floating ice.

The theory of striation of rock surfaces by floating ice-masses transported in different directions by oceanic currents, tides and winds as they grounded on the bottom, has long been held, but it is to this day, nevertheless, a subject of dispute among glacialists. It is proposed, briefly, to place on record by descriptions and illustrations certain ice-markings believed to have been produced by floating ice, and to demonstrate, from the local circumstances and peculiar situations in which they occur, that they cannot have been produced by land-ice.

Character of floating ice which striated the rocks of this region.

Floating or sea-borne ice is of several kinds. First, there are the solitary bergs drifted about by currents and tides, which gradually melt and crumble to pieces as they are carried southward from arctic regions into warmer seas; second, ice-floes, pan-ice, or drift-ice made up of low-lying, loose, flat sheets of greater or less area, driven by winds, tides, or currents. These often cover several square miles of the ocean surface. And, third, what for want of a better name I have called ice-jams, which are large masses of floating ice forced into straits or inlets by land ice, or by currents or winds, so compactly, that a jam of this kind moves as one body similarly to land-ice. These are, I believe, often called ice-packs. Ice-jams occur in Smith's Sound, and north of that between the coasts of Greenland and Grinnell Land, and elsewhere in arctic regions. The low, flat sheets of the second class, by being driven into straits and narrow passages may become ice-jams. Ice-packs, or jams appear to be the only kind of floating ic

capable of producing regular striæ. The striation of the low-lying ledges in the St. Lawrence estuary, extending north-eastward and south-westward, appears to be due to ice of this character. In the Baie des Chaleurs basin, and on the north-east side of the Isthmus of Chignecto, as well as on the Cape Tormentine peninsula, striation caused by ice-jams prevails. Ice of this kind has also impinged heavily against the north-east and south-west coasts of Prince Edward Island. Separate icebergs, or loose floating ice-masses, do not, as a rule, produce scoring of rock surfaces in the same way as ice-jams. The writer has, winter after winter, for many years investigated the ice phenomena of the south-western embayment of the Gulf of St. Lawrence, but has failed to discover from the action of the coast-ice, or of the loose floating masses driven about by the tides, winds and currents, any evidence of regular striation from these. They remove the asperities and polish rock surfaces, but having little or no sand or gravel adhering to the under sides, their erosive power is insignificant, and they leave no striæ. Ice-jams, on the contrary, are forced over low shoals, or up against low banks, and even across points of land, carrying more or less of the loose gravel, sand, etc., with them, and their pressure and eroding power are in certain places as great as that of land ice. In many parts of the region striæ are met with on the lower slopes, running parallel to the coast, which have doubtless been produced by ice-jams, the margins of which ground along the bank in their onward movement as if impelled by an almost irresistible force. Examples of striæ produced in this way are found at Belledune, Cocagne, along the coast of Prince Edward Island, and in a number of other places.

Where floating ice striæ were observed.

Detailed accounts of the evidences of floating ice as occurring in the estuary of the St. Lawrence, on the south-west side of the Baie des Chaleurs, etc., were given on page 83 M. In eastern New Brunswick, especially on the Isthmus of Chignecto, a number of interesting facts have been observed respecting the action of floating ice. Ice-jams, or packs, have crossed from Northumberland Strait to the head of the Bay of Fundy, and probably also in the reverse direction. The striæ effected by these were observed at Baie Verte, also on the axis of the isthmus, and on the Cape Tormentine peninsula. In the last-mentioned locality, the same ledges exhibit evidences of both northward and southward ice-movements very distinctly. (See list of floating-ice striæ Nos. 9 and 16.) That they cannot have been produced by other agencies than floating ice, is shown by the fact that no striæ corresponding in direction with these have been found crossing Prince Edward Island. The southward-moving floating ice which produced these striæ must, therefore, have come either by the

north-west entrance of the strait, or across the low-lying portion of Prince Edward Island, then submerged, immediately to the west of Richmond and Bedeque bays, or by the eastern entrance of Northumberland Strait. In fact it would seem to have come in by both the eastern and north-western passages simultaneously, thus forming the ice-jam already referred to, which sought outlet across the Isthmus of Chignecto into the open waters of the Bay of Fundy. But a portion of the floating ice coming in from the east, must have surged across the then existing shoal now forming the low peninsula of Cape Tormentine and produced the northward-trending striæ there. That floating ice in any considerable quantity came across the submerged Isthmus of Chignecto from the Bay of Fundy to Northumberland Strait seems somewhat doubtful, as no striæ with stossing on the south-west side of the ledges have been met with around the head of that bay. The chief currents and the principal ice and drift transport were apparently from north-east to south-west, into that body of water.*

Floating ice striæ on the coast of P. E. Island.

Around the shores of Prince Edward Island, striæ, evidently produced by floating ice, at a time when the land stood lower than now, are numerous. None of these cross the island in any direction; but have apparently been formed by floating ice impinging obliquely against both the north-east and south-west shores at the period referred to.

To the west of the Isthmus of Chignecto, or the head of the Bay of Fundy, the action of floating ice could not be traced on the New Brunswick coast border.

General Conclusions.

General conclusions regarding the glaciation of the region.

Summarizing the principal facts relating to the Pleistocene glaciation of the region under review, it is found that at the period of the maximum extension of the ice, there was a general radial movement from the main *nevé*-ground of the north-east Appalachians, northward and eastward into the St. Lawrence Valley, eastward into the south-western embayment of the Gulf of St. Lawrence, south-eastward into the Bay of Fundy and Atlantic Ocean, and southward and southwestward in United States territory.

The St. Lawrence Valley, as far westward as the Thousand Islands, was probably an open channel in the latter part of the glacial period at least, into which ice flowed from the north and from the south.

*In the spring of 1894, ice-jams were driven into Northumberland Strait, and the passage between Cape Tormentine and Cape Traverse was blocked up by them to a depth of thirty feet, according to newspaper reports and travellers.

Although the Appalachian glaciers here referred to were not of great superficial extent, the ice which occupied New England and south-eastern Quebec seems to have been the thickest and heaviest of the Pleistocene glaciers of eastern North America, developed in these latitudes; and the geographical and meteorological conditions favour the view that it was only surpassed in this respect by the great Cordilleran glacier of the west.

In eastern Canada, south of the estuary and Gulf of St. Lawrence, the land ice seems to have consisted of local glaciers, and the different parts which streamed outwards from the central *nevé*-grounds have been differentiated and received separate names. That which occupied the Gaspé peninsula and the Notre Dame Range, followed the drainage channels, generally speaking, in its descent northward and southward. Along the lower St. Lawrence, the flow was apparently into the open waters of the estuary, while at Gaspé Basin it was eastward directly into the waters of the Gulf of St. Lawrence. Direction of ice flow.

The western part of the Baie des Chaleurs valley was occupied by a sheet to which the name of the Baie des Chaleurs glacier has been given. South of this and mantling the greater part of the Carboniferous area of New Brunswick and Prince Edward Island, the Northumberland glacier was developed. The great valley of the St. John River and the slopes on either side, were occupied by a sheet of ice which has been designated the St. John Valley glacier. The east and south-east termini of these glaciers were attenuated and were not accompanied by moraines. During the epoch of maximum ice accumulation, the coast border was somewhat higher than at present. Subsidence and differential movements set in towards the closing stage of the glacial period, which, in the Carboniferous plain of central and eastern New Brunswick, are evidenced by a number of swerving courses of striæ. These indicate that the watershed between the drainage basins of the St. John River and the rivers falling into Northumberland Strait, did not partake of the downward movement of the coast border to such an extent as the latter. The striæ which show gradually swerving movements on the flat Carboniferous plain, may be taken as evidence that there was no withdrawal of the ice from the region during the whole glacial epoch. Towards the closing stage, the glaciers became smaller and more detached, and floating ice occupied the bays and straits. The markings left by the latter on rock surfaces, show that the coastal parts of New Brunswick were then from 75 to 150 feet lower than at present. The country around the Baie des Chaleurs and that on the northern coast border of the Bay of Fundy, seem to have undergone greater differential changes of level than the central Carbonifer- Separate glaciers.

ous area of New Brunswick and Prince Edward Island, the latter area apparently occupying a more stable attitude in regard to crustal oscillations. The subsidence inaugurated then was that which continued into the Leda-clay period.

The peninsula of Nova Scotia was glaciated by land ice which gathered upon its surface, and probably by floating ice in the coast districts at a subsequent stage.

A local glacier seems to have accumulated around the head of Chignecto Bay and upon the isthmus of the same name, in the early stage of the Pleistocene, which has been called the Chignecto glacier. Floating ice has also glaciated the isthmus at a later date.

Magdalen Islands non-glaciated.

On the Magdalen Islands no evidences of Pleistocene ice-action, or of the occurrence of boulder-clay, were observed ; on the contrary, the rock surfaces are everywhere masked with a covering of their own débris.

The glacial period; was it due to local or general causes?

The cause or causes of the glacial period, or rather of the existence of sheets of land ice in these latitudes in Pleistocene times cannot be discussed here. But it may be remarked that the tendency to eliminate cosmic influences and attribute the refrigeration of the northern part of this continent to geographical or terrestrial causes, characteristic of later studies respecting glacial phenomena, does not seem, so far, to throw a great deal of light on the question, and may after all be only a partial view. If the glacial period be solely due to terrestrial causes, the fact that such causes must be largely of a local character appears to have been overlooked ; for, it is not probable that these causes would act synchronously in the whole arctic and north temperate zones as far south as the limits of the glaciated belt. That changes in the elevation of the land, changes in the distribution of land and water, changes in the atmospheric and oceanic currents, a greater or less amount of moisture and precipitation than what now obtains, etc., are, taken together, sufficient to bring about a glacial epoch, such as the phenomena indicate must have existed in Pleistocene times, may be seriously doubted. If it were attempted to show that such terrestrial conditions were sufficient to produce a glacial era locally, on one side or the other of the North American continent, for example, or on both sides of the North Atlantic, the hypothesis would seem to be adequate; but these causes while competent to produce various local oscillations of climate and of glacial conditions, have probably been governed or modified by some general law. It is inferentially certain, therefore, that any hypothesis based on terrestrial conditions which may be propounded will have to include such general or cosmic influences as to affect simultaneously the whole

circumpolar and north temperate regions of the earth during Pleistocene time, otherwise glacial conditions cannot have occurred synchronously in both hemispheres, or even on both continents.

Deposits of the Later Pleistocene.

(*M. 2 a*). *Stratified Inland Gravel, Sand and Clay (Fresh-water).*

The general character of the stratified inland deposits and their relation to the boulder-clay and other superficial materials of the region, have been discussed in previous reports, and little can be added from our investigations regarding them during the past four years. Almost everywhere above the highest Pleistocene shore-line, and sometimes extending down below it, they mantle the glacial deposits proper and the residuary materials to a greater or less depth. Sections of these deposits are given in my reports on north-eastern and southern New Brunswick,* which are applicable to the area here discussed, it being part of the same Carboniferous field. Deposits of the later Pleistocene.

This member of the surface deposits has not hitherto received adequate study and correlation in glaciated countries, owing largely, perhaps, to the theories at present in vogue. By some geologists these deposits are attributed mainly to glacier action, or rather to the action of waters resulting from melting glaciers; and the terms *glacial gravels, glacial sands*, etc., are not infrequently met with in the literature of the subject. On the other hand, the advocates of great submergences suppose that they have found, in these deposits, and especially in the river and lake terraces which form a part of the series, evidences in support of their hypotheses. Our investigations have not elicited any large array of facts in favour of either view. As stated in previous reports, there is some evidence in the lower portions of the series, in certain places, that the deposits are the product of glaciers, that is, have probably been formed by waters flowing out from the foot of melting and retreating ice-sheets; but by far the greater portion of the series does not seem to have been produced in this way, but rather by agencies which are in operation at the present day. Again, as regards the hypothesis of submergence, all the terraces and other water-laid deposits above the highest post-glacial shore-lines recorded on pages 22-25 M, seem to be explicable on the theory of their having been produced by fluviatile and lacustrine agencies. Terraces along river-valleys, as a rule, slope longitudinally in the direction in which the river Stratified fresh-water deposits.

*Annual Report Geo. Surv. of Can., vol. III. (N.S.), 1887-88, p. 17 N; and vol. IV. (N.S.), 1889-90, p. 52 N.

flows; those in inclosed basins can be accounted for by the action of the waters around the margin of existing or extinct lakes. This explanation applies to the formation of terraces at all elevations above the marine limits of the Pleistocene above mentioned, and obviates the necessity for postulating a great submergence of the region. The presence of the boulders met with on these higher levels has sometimes been explained as due to the action of floating ice during this supposed period of submergence, but no boulder-clay or other glacial material occurs, so far as my observations have extended, overlying or interstratified with these terraced and associated stratified deposits. Transported boulders, often worn and glaciated, occur on the surface, it is true, but their presence there I regard as due to the denudation of the original boulder-clay, of which they formed a part, and to subsequent erosion and transport by fluviatile, or lacustrine action, or it may be to the simple wear and waste of the surface deposits alone by subaerial agencies, gravitation causing them to move from higher to lower levels simultaneously with the general lowering of the land consequent thereon.

How formed.

These inland, stratified gravels, sands and clays are, therefore, the result mainly of a long series of complex causes which have been in operation since the close of the glacial period. Eliminating those supposed to have been formed by waters due to melting glaciers, we find that the products of fluviatile and lacustrine action lie chiefly in the valleys and depressions, where the deposits are often thick, and evince the changes and fluctuations of the floods which have produced them. On the higher ground between the valleys, these beds are of varied thickness, from a few inches on some hills and slopes, to many feet in the hollows, and seem, as stated above, to have been formed, to a large extent, by ordinary subaerial agencies, such as frost, rains, the melting of each winter's snow, etc., all of which have a denuding effect when continued year after year. In some hollows they are produced by the wash from the hills, and usually contain lenticular seams of clay. The materials are all derived from the boulder-clay and residuary earths of the region.

White bleached sands.

Upon the Carboniferous area of the eastern maritime provinces, the upper strata of this division of the superficial deposits contains irregular, lenticular, bleached seams of gray or whitish sands, especially noticeable in newly-ploughed fields. This colour is due to the deoxidation of the iron in the materials through the action of the vegetation growing on the surface.* The questions pertaining to the origin and mode of occurrence of these inland stratified beds is a very important one

* Annual Report Geol. Surv. Can., vol. III. (N. S.), 1887-88, p. 17 N.

and we propose to investigate it in still greater detail when we come to study the valley of the upper St. John and the region adjacent thereto.

River and Lake Terraces.

Terraces occur along the Southwest Miramichi River and its tributaries, notably at Doaktown and Boiestown, also along the Renous and Dungarvon rivers, and, in certain places, attain a considerable development. But along the rivers whose drainage basins are entirely within the Carboniferous area, whether in New Brunswick, Nova Scotia or Prince Edward Island, no high or remarkable terraces have been met with. River and lake terraces.

Reference has been made to the mode of origin of river and lake terraces. These terraces are found to be mainly attributable to the action of the rivers and lakes themselves upon the materials in the valleys in which they lie. Boulder-clay is occasionally met with beneath the river terraces, especially under the higher ones; and it seems also probable that the stratified basal portions of these, at least, may have been built up by deposits of material transported by the waters of melting glaciers during the period of their retirement. Around lake margins, both stratified and unstratified deposits occur in mounds and ridges, associated with or forming part of the terraces or benches. These have been produced by the mechanical expansion or shove of the ice that covers their surfaces every winter. Mode of origin of.

The discussion regarding the formation of river and lake terraces in previous reports, has been so ample as to include all that is necessary to say on the subject till further observation and study of those so typically developed along the St. John River and in western New Brunswick are completed, when it is hoped additional facts will be obtained enabling us to elucidate some of the problems presented by this very interesting class of formations.

(M. 2 b.) Leda Clay and Saxicava Sand.

In the region bordering Northumberland Strait, the Leda-clay and Saxicava-sand deposits exhibit a marked difference from the beds of the same formation in Baie des Chaleurs basin, or on the coast of the Bay of Fundy. Around these bays the Leda clay is often well developed, ranging in thickness from five or ten to fifty feet or more. The lower part is usually coarse, and contains boulders derived from the boulder-clay or residuary material, and sometimes graduates into the former, or rather is without any sharp line of demarkation separating the two, and not infrequently is unfossiliferous. The upper portion consists of finer Leda clay and Saxicava sand.

materials, as a rule, and wherever these are at all calcareous, marine fossils are present in greater or less abundance. The strata most prolific in marine shells are those immediately in contact with the overlying Saxicava sands. Attempts have been made to classify the Leda clay into upper and lower. Palæontologically, perhaps, such a division is possible, though it may after all be one mainly dependent on the bathymetric conditions under which the marine mollusca existed; but no stratigraphical break such as that occurring between it and the overlying Saxicava sands has anywhere been met with in the Leda clay itself. This and the Saxicava sand almost everywhere consist chiefly of local material derived from the subjacent beds, with more or less transported water-worn sand and gravel, etc., intermingled. In districts occupied by limestones, shales or slates, which in their decay form clay beds, the Leda clay is found especially well developed, and usually contains fossils; where, on the contrary, the underlying rocks are sandstones and grits, the Saxicava sands occur in their greatest extent and thickness, and the Leda clay is thin and irregular, or else entirely wanting.

Scarcity of Leda clay in the region examined.

In the region bordering Northumberland Strait, the Leda clay is seldom met with pure, and then only a few inches in thickness. Wherever these meagre clayey strata occur in the sandstone area, there only have marine shells been found. The Saxicava sand is, however, always present and generally of great thickness, and apparently has been formed in a manner similar to the sand flats of the recent period, *i.e.* along the littoral. The upper strata usually contain coarse material with local and transported boulders. None of these arenaceous beds have hitherto yielded fossils. Indeed only in a few localities on the west coast of Prince Edward Island have fossils been found in the whole Carboniferous basin, and they are few in number. Sections of these beds will now be given in detail, in descending order, and the contained species of shells enumerated:—

Sections of these marine deposits.

At Miminegash, P. E. I.

1. Half a mile south of the point of land at Miminegash Pond a measured section shows:—

(1.) Saxicava sand { Stratified gravel, 4 feet
Fine grained sand, 3 "
——— 7 feet.

(2.) Leda clay, soft and unctuous, 12 to 15 inches.

The fossils occur in the upper part of the Leda clay, the species being *Saxicava rugosa*, *Balanus crenatus* and a *Leda*, probably *pernula*.

(3.) Boulder-clay, to the beach at high tide level, 20 feet.

At Campbellton, P. E. I.

2. At Campbellton another section exhibits the following series:—

(1.) Saxicava sand { Stratified gravel, 4 to 5 feet
Fine sand, 6 feet or more
——— 11 feet.

(2.) Leda clay, quite thin, not more than a few inches. In upper part, or between it and the overlying Saxicava sand, the following shells were found :— *Saxicava rugosa*, *Mya arenaria ?* *Lunatia*, sp.?

(3.) Boulder-clay, thin.

The bank here is about 25 feet high, but more than half of it is rock.

3. South of Cape Wolf a third fossiliferous bed occurs in which Mr. Wilson found shells of *Macoma Grœnlandica.* A section of the beds is as follows :— Near Cape Wolf, P.E.I.

(1.) Saxicava sand (gravel and sand), 11 feet.

(2.) Leda clay, thin, the sliding down of the beds prevented measurements being made.

(3.) Boulder-clay, thickness not known, but this and the Leda clay taken together are upwards of 15 feet thick above the beach.

The highest Pleistocene shore-line on Prince Edward Island is about 75 feet above mean tide (page 25 M) ; on the mainland around Northumberland Strait it is found to be from 125 to 140 feet, the lowest being on the Cape Tormentine peninsula. Marine terraces are everywhere common up to these heights. Shore-lines occur at lower elevations, as, for example, on Prince Edward Island where a well-defined one was observed besides that mentioned above, at about 50 feet above mean tide level, and at Wallace, N.S., on the mainland, distinct, wave-built terraces occur at 130, 120, 110 and 55 to 60 feet, etc. Height of the Pleistocene, or post glacial shore-line in P. E. I., etc.

Around the head of the Bay of Fundy, the Pleistocene uplift, though differential, was greater than in Northumberland Strait ; but the marine terraces are not well defined, except in a few localities, and have proved so far to be without fossils. Two circumstances have been unfavourable to the preservation of marine shells in them, (1) the heavy tides and currents, and (2) the presence of iron and other minerals in the deposits tending to corrode and destroy them. Scarcity of marine fossils.

In the sections of the marine beds of the recent period exposed at the Fort Lawrence dock, at the west end of the Chignecto marine railway (page 127 M), the Pleistocene marine deposits, if represented at all, are poorly defined and problematical. Certain strata between the boulder-clay and the peat, or forest bed, may be taken either as residuary material or oxidized boulder-clay, or as partly boulder-clay and partly Saxicava sand. The absence of fossils renders this uncertain. There is no doubt that the Isthmus of Chignecto was submerged in the later Pleistocene, but the erosion to which it was then subjected may have prevented the deposition of any but thin beds of marine sediment. The materials of which the superficial deposits of the region, on either side of the isthmus, are composed, are not favourable to the preservation of marine testacea, however, there being little or no lime in them. It is not at all improbable, therefore, that shells Marine beds at the Chignecto railway, doubtful. Reasons why fossils are scarce in deposits on south side of Gulf of St. Lawrence.

have been entombed in the marine Pleistocene beds at the head of the Bay of Fundy and around Northumberland Strait, in many places in which they are not now to be found. Shells are abundant there now along existing sand beaches, and in the littoral, and it is only reasonable to suppose that the mollusca of the Leda-clay and Saxicava-sand period lived in these waters. But the deoxidation of the iron which the sands contain and the purifying processes they undergo, rapidly destroy shells when they are once buried in them. The scarcity of Pleistocene shells in these marine terraces, therefore, is to be accounted for mainly from the destructive processes referred to, and not from their supposed absence or paucity in the adjacent seas, during the formation of the terraces.

Terraces in Cobequids supposed to be marine.

Terraces or deltas 171 feet above mean tide level (page 24 M), supposed to be marine, occur at Halfway River at the northern base of the Cobequid Mountains; and at Lakelands, in the pass through which the Springhill and Parrsboro' railway runs, others were observed 223 feet high. In regard to the 171-foot terrace or delta, it may be stated, the materials are stratified gravel and sand which, near West brook, are irregularly bedded, and differ from those composing the Boar's Back, inasmuch as they contain crystalline boulders from the Cobequids scattered throughout the mass. The materials have been brought into the valley by West Brook, and the terraces exhibit faults or dislocations in places, which may be regarded as indicating differential movements since the period of their deposition.* At first it was supposed these deltas or terraces were of lacustrine origin, but a system of levellings showed them to be eighty-five and one hundred and thirty-five feet, respectively, above the bottom of the pass referred to and from forty to ninety feet higher than the summit of the Boar's Back along River Hebert valley. On the lacustrine theory of their origin, we would have to postulate two dams, one to the south, in the Cobequid Pass mentioned, another to the north in River Hebert valley, in order to hold up a lake even at the height of 171 feet. This difficulty at once renders the lacustrine hypothesis of the origin of the terraces untenable. Moreover, it was observed that the terraces extend northward towards the Upper Maccan River, though at a diminishing height, and southward through the pass referred to, apparently increasing in elevation, though considerably broken up and denuded. On the south side of the Cobequids, near Parrsboro', where they face the Basin of Minas,

Difficulties of lacustrine theory of their origin.

*South of Dorchester Cape, Westmoreland county, N.B., in a bank along the shore, faults or dislocations were also observed in the superficial deposits. The materials are a stiff arenaceous, stratified clay, resting on boulder-clay, and the faults, of which there are six or eight, are nearly vertical, the *hade* being slightly to the south-east, with the downthrow to the north-west, that is, on the side away from the Bay of Fundy.

they fall to a level of 130 or 135 feet above mean tide. It seems to me, notwithstanding these inequalities in height, that all these terraces and deltas mark the upper limit of the post-glacial upheaval, or the height of the sea during the Pleistocene subsidence of the land, and are, therefore, marine. The differential elevation shown between these and the shore-lines along Northumberland Strait has been explained on page 30 M. The dislocations in the terraces may be taken as evincing unequal vertical movements. Remnants of terraces, or shore-lines, at the same height as those described, were observed on the west side of the valley through which Halfway River flows. These as well as the front of the main terrace itself have been sorely denuded. They are evidently of the age of the Saxicava sands of the Gulf of St. Lawrence and have been formed under similar conditions.

Later terraces in Halfway River valley.

At a subsequent stage of post-glacial history, as the land rose and the sea withdrew from Halfway River valley it formed a catchment basin and held in a fresh water lake of which Halfway Lake is a remnant. This lake stood about thirty feet higher than the present lake, or eighty-nine and a half feet above mean tide level. Terraces and alluvial flats formed by it encircle the valley now inclosing Halfway River and lake.

Importance of terraces here in relation to differential movements.

The facts respecting the terraces in this locality are of great interest, and if the higher terraces are marine, as they certainly seem to be after eliminating all other theories as to their mode of origin, they are most important in their bearing on the question of differential upheaval in this region during the Post-Tertiary period.

Age of the Leda clay and Saxicava sand

The Leda clay is found in some places resting on rock surfaces which have been striated by the local ice-sheets and floating ice of the closing stage of the glacial period. No disturbance of these beds, which must have been subsequently deposited, seems to have taken place, nor have any intercalated or overlying glacial products been met with in connection with the Leda clay and Saxicava sands. Hence it is inferred that their deposition began about the close of the boulder-clay period and continued for some time after the retirement of the ice from this region.

Correlation of these deposits with the Leda clay and Saxicava sand of the St. Lawrence Valley.

These fossiliferous clays and sands have been closely correlated with the Leda clay and Saxicava sands of the St. Lawrence valley, studied and named by Sir J. W. Dawson many years ago, and seem really to constitute a part of the same series deposited in the southern embayment of the Gulf of St. Lawrence, the only difference in the marine fauna being that in the latter area a few southern species are intermingled with those of the boreal type. The exact relations of a number of these species have not yet been definitely worked out, however, and until

further collections of both Pleistocene and existing shells are made on the east coast of Canada, especially in and around the Gulf of St. Lawrence, their value as indicative of the climate of later Pleistocene times, and of the depth of the sea in which they lived is not to be greatly relied on. Some additional dredgings would be important in this connection, as enabling us to correlate the marine fauna now inhabiting the coast waters more closely with that of other regions, as well as with that of the Pleistocene deposits under consideration.

(M 3 *a.*) Fresh-water Deposits of the Recent Period.

River-flats (Intervales).

Deposits of the Recent Period (river-flats). Where observed in New Brunswick.

River-flats skirt the principal rivers of the region to which this report relates, and usually form the best soils. Along the Southwest Miramichi and its tributaries they are cleared of forest in many places and cultivated, and at Doaktown and Ludlow on the main river attain a considerable width. Bordering the Renous River, about thirteen miles from its mouth, fine, wide flats, partly under cultivation, but mainly covered by forest still, were also observed. These nourish a splendid growth of elm, balsam-poplar, yellow birch, etc., and if cleared and properly tilled should be valuable for the production of hay and for raising stock. Flats also occur along the Dungarvon River, one of which, eight miles above its confluence with the Renous, has yielded hay for many years. Similar intervales border the Kouchibouguac and Kouchibouguacis rivers, also the Richibucto, Buctouche and Cocagne rivers. Those along the three last-mentioned streams are largely under cultivation and afford good soil. Excellent farms were seen in the Richibucto Valley, and especially along two of its chief affluents, Nicholas and Coal Branch.

The rivers of Albert and Westmoreland counties do not possess any river-flats worthy of mention, being small and their drainage basins of limited extent.

In Nova Scotia.

In Cumberland county, Nova Scotia, intervales stretch along the Upper Maccan River and occur again at Halfway Lake, where some good farms were observed. Narrow margins of intervale land border River Philip and the Pugwash and Wallace rivers, while in the Deware valley and farther east towards Tatamagouche, some fine alluvial bottoms exist. Nearly all the alluvial soils are under cultivation in Cumberland county.

In Prince Edward Island.

Crossing Northumberland Strait and reaching Prince Edward Island, we find no fresh-water alluviums of note there except along the Dunk and Hillsborough rivers, the former only being within the area

of sheet No. 5 S.W. All the valleys of the smaller streams, of course, contain more or less bottom-land, but usually it forms only a very narrow strip. The character of the soil derived from the soft Permo-Carboniferous and Triassic shales is such, however, that it readily crumbles down into a fine loam, and this mantles the slopes and bottoms of the valleys to a greater or less depth, and is almost equal to an alluvial soil. Much of it, indeed, is of the nature of fresh-water alluvium, though for the most part due to subaerial, or atmospheric action.

The mode of formation of these deposits has been discussed in former reports. They are in every instance the result of seasonal changes, such as spring and autumn floods due to melting snow, rains, etc, and the sedimentation consequent upon silt transportation from such floods. These carry coarse and fine material, the former being first dropped, the more finely comminuted matter transported farthest and deposited in the lake-like expanses of the rivers, or wherever their flow becomes slackened sufficiently to permit deposition of the fine sediment held in suspension by the waters. In these alluviums stratification is seldom apparent, except where clay is present in greater or less quantity, and in this respect they may be said to resemble the loess of other countries. No fossils have been found in them except stems of shrubs, twigs and leaves, remains of herbaceous plants, etc., all of which belong to existing species. Mode of formation.

Peat Bogs.

Peat bogs are well developed in the coastal region of the south-western embayment of the Gulf of St. Lawrence, especially in New Brunswick and Prince Edward Island. Besides those described in former reports as occurring on Miscou and Shippegan Islands, at Saint Simon Inlet and at Pokemouche, Tabucintac, Cheval and Escuminac Points, others were noted at the following localities and are delineated on the maps accompanying this report. The following is a list of those observed in New Brunswick:— Peat bogs. Where observed in New Brunswick.

1. An extensive peat bog lies on the north side of Kouchibouguac harbour.

2. Another occurs on the coast about a mile south of the mouth of Kouchibouguacis River and faces the sea.

3. A third occupies part of the peninsula between the estuary of the Aldouane and the coast. This bog is large and raised in the centre and merges into the salt marsh on the shoreward side.

4. On the south of Little Gully at Richibucto Head, inside of the sand beaches, there is a peat bog of considerable extent.

5. Two large bogs occur along the Kent Northern railway, from one to five miles above Kingston, or about 20 or 21 miles from Kent Junction, Intercolonial railway.

6. About six miles north of Rogersville station, Intercolonial railway, and north of the first crossing of Barnaby River, a large peat bog occurs. It is a shallow one and a portion of the area mapped as peat bog forms a shallow lake, spring and autumn.

7. About two miles south of Canaan station, Intercolonial railway, a peat bog crosses the track twice.

8. Peat bogs skirt the lakes at the head of Missaquash River on the Isthmus of Chignecto.

In the interior of the country, flat peat bogs are of frequent occurrence on the watersheds, or undrained portions of the Carboniferous area, but they are usually shallow and the peat thin, poor and dirty, being mixed with the wash from the surrounding slopes. These bogs support a scanty growth of black spruce, hacmatack, etc., especially around the marginal portions. The best and cleanest peat is that found growing on the raised bogs.

In Prince Edward Island.

Proceeding to Prince Edward Island, we find large peat bogs on the north-east side, along the shores of Richmond and Cascumpeque bays. These have been described by Dawson and Harrington.* The precise localities of the largest peat bogs on the island are here noted :—

9. At Lennox Island, Richmond Bay, on the north-east side, a strip of peat faces the Gulf of St. Lawrence. This bog is apparently being rapidly eroded by the sea.

10. At Point Lot 12, there is an extensive peat bog (called the Squirrel Creek bog in Dawson and Harrington's report already referred to), covering an area of certainly not less than 500 or 600 acres. It rises in the centre, and like those on Miscou and Shippegan Islands, at the entrance of the Baie des Chaleurs, is dotted over with small, deep ponds or holes in the peat which remain constantly filled with water. It is also treeless.

11. At Black Bank, east of Stephen Cove, in Cascumpeque Bay, there is also a large peat bog. Along the shore it is seen to be ten or twelve feet deep in places and rests directly on white sand. The bottom layers are full of roots, trunks of trees, etc., in decay. Just at Stephen Point, stumps were observed two feet below low water mark. This bog is also higher in the centre than at the circumference, and treeless. Erosion by the sea is apparently making rapid inroads into it. Mr. Robert Tuplin, who lives in the vicinity, and has been making

*Report on the Geological Structure and Mineral Resources of Prince Edward Island, 1871. By Sir J. W. Dawson and Dr. B. J. Harrington

observations on these peat bogs, informed us that a strip of five feet in width or so was annually worn away by the sea. This peat bog is described in detail in Dawson and Harrington's report already cited and its area can be best learned from an inspection of the map.

12. West of Stephen Cove, another large peat bog, the largest on Prince Edward Island, occurs (see map). It is about three-quarters of a mile wide, and, like those of Black Bank and Squirrel Creek, is raised in the centre and without trees.

13. A small peat bog was also seen near Portage station, P. E. I. railway.

Roots and stumps in peat bogs.

All the peat bogs bordering the sea are found to extend down under high tide level and their lower parts contain roots and stems of trees which do not occupy their surfaces at the present day, but which, nevertheless, exist in the low, flat, swampy coastal tracts in the vicinity. In some countries where peat and treeless moorlands exist, attempts have been made to show that these buried forests must have been destroyed by the encroachment of the sea, or by a change of climate, or in some other unaccountable way, before the peat mosses began to grow. But as peat bogs in what may be termed their incipient stages are not infrequent in many parts of the maritime provinces of Canada, on the surfaces of which the same stunted growth of spruce, hacmatack, cedar, etc., prevails as is found in the bottoms of the larger bogs, it is at once evident that the change from a forest-covered or partially forest-covered condition in the early stages of their growth to a treeless condition when they are mature, or rather when the peat has attained considerable thickness, is one due to other causes than those mentioned.

Mode of growth of peat bogs.

Peat bogs are to be seen in all stages of development in this region, from those only a few inches or a foot or two deep, to those upwards of twenty feet deep. The first have always a forest growth upon them when in their natural state, the trees being larger around the margins than in the centre. As the peat mosses grow and the bog increases in thickness, the trees are observed to become stunted, and finally die out wherever the peat is thickest, generally at the centre first, then outwards towards the circumference. The larger and thicker bogs at present have, therefore, a part which is treeless, and a border upon which there is an ericaceous growth, occupied with some stunted forms of spruce, hacmatack, cedar, etc., the latter increasing in size and becoming more and more intermixed with other trees towards the margin of the bog. From this fact it would appear that trees do not, or cannot, grow in peat bogs, and that, therefore, their treeless condition is mainly due to the drowning out of the forest growth which

Why trees do not grow in them.

originally occupied the area on which they lie. The growth of the mosses causes imperfect drainage, the peat in its natural state holding from ninety to ninety-five per cent by weight of water. It is at once obvious that trees will not grow in such a soil, and even if rooted in that beneath the peat, the accumulation of several feet of wet, cold, peat mosses around the base of their trunks and the lack of aeration to their roots must soon result in their death. In the early stages of the growth of the peat bog, there would doubtless be a struggle for the mastery between the forest growth and the *sphagna*; but as peat bogs invariably accumulate in hollows or basins which originally held shallow lakes, and do still, when not wholly occupied with peat, receive, at certain seasons, the drainage of the surrounding area, it will be seen that tree growth in peat, even then, is placed under very unfavourable conditions for its development at anything like a rapid rate. In consequence of this it is only those hardy species found in wet, cold soils, in swampy tracts, that grow at all in those hollows, before or during the incipient stage of the growth of the peat bogs, and their existence is often a very precarious one, liable to be checked or terminated altogether by any untoward or unfavourable change. Hence the growth of peat moss around the roots and basal part of the stems ultimately destroys the trees. They then stand as dead trunks for some time, until decay setting in, they break off at the surface of the bog, the trunks falling prostrate upon it. But the roots, and sometimes a portion of the stump are preserved from decay by the antiseptic properties of the peat moss, or the acids generated by its decay, and are usually found in a sound condition at the present day, sometimes even with the bark intact.

Climate of the region favourable to the growth of the *sphagna*, composing the peat beds.

The great thickness and extent of so many of the peat bogs, or moorlands, near the coast of New Brunswick and Prince Edward Island, shows that the existing climatic conditions are very favourable to the growth of the species of *sphagna* and other vegetable forms composing them. And from the peat, or forest beds, found under the marsh mud at Aulac station, Intercolonial railway, and at the west dock of the Chignecto marine railway, it is evident that somewhat similar meteorological conditions prevailed throughout the recent period. We may even go further back, and infer from the peat beds found by Sir J. W. Dawson under the boulder-clay at River Inhabitants, Cape Breton, that the climate of the coast in the later Tertiary did not differ very much from that which now obtains.

Antiquity.

The peat bogs, or moorlands, are, therefore, of considerable antiquity, having commenced their growth in this region along the coast, as soon as the land emerged from beneath the sea in post-glacial times.

They did not all originate then, however, but at intervals, or from time to time, as the habitat of the *sphagna* and the drainage and other conditions became favourable for their development.

As has already been inferred, the peat bogs indicate a slight subsidence of the coast border within the recent period. The exact amount of the change of level is a difficult matter to ascertain ; but the facts point to a depression of from five to ten feet.

Subsidence indicated by the peat bogs.

No use has yet been made of peat in the region embraced in this report. A number of these bogs are easily accessible, some by land and others by water ; but the abundance of wood and the proximity of the Nova Scotian coal mines keeps fuel at moderate prices, and there is consequently no use for peat in that way. The day will come however, when it will become valuable, not only for fuel and litter but for other purposes as well. In some parts of Europe it is now utilized in various ways. One of these is as a packing material for the transport of the various kinds of crockery, glass and other articles liable to breakage. Another is in its taking the place of ice in the carriage of perishable articles, such as fresh meat, fish, etc. When cut into fragments it is said to be well adapted for the preservation of these articles in transport in warm weather, either by railway or water. Meat when packed in it, will keep fresh for weeks, and will eventually become dry, the moisture being absorbed by the peat. For the shipment of fresh fish by railway it might be utilized to great advantage on the Atlantic coast of Canada ; salmon, cod, mackerel, lobsters, etc., by this means finding a market, not only in the eastern cities of the United States, but in Montreal, Ottawa, Toronto, etc Peat has also been successfully used for preserving fresh fruit ; even grapes it is said can be made to retain their freshness unimpared for months if packed in finely pulverized moss litter. Its uses as a non-conductor of heat, therefore, are likely to bring it into extensive requisition in this country in the near future.

Uses to which peat may be put.

In Germany peat has been used for years as an absorbent of the waste liquids and refuse of factories, and in this way it has furnished large quantities of excellent manure in certain districts. An excellent fibre is also now manufactured from some varieties of peat, susceptible of being woven and applicable to other purposes. An enumeration of the manifold uses of peat would prove that this raw material is eventually destined to become of great value in the arts, in chemistry, and in agriculture, as well as for sanitary purposes. Bog land hitherto regarded as worthless, is likely to become valuable property, and flourishing industries promise yet to spring up from the use of this neglected material. When that day arrives the maritime

Uses in Germany.

Value of moorlands.

provinces of Eastern Canada will be able to furnish an almost unlimited supply of peat moss for all the purposes enumerated.

(M 3 *b*.) Marine Deposits.

Dunes, Salt Marshes, Estuarine Flats, Mussel-mud, etc.

Recent deposits (marine)

The recent marine deposits which occur almost everywhere around the coasts of New Brunswick, Nova Scotia, and Prince Edward Island, are among the most interesting of the superficial formations. Their great development in the particular region under discussion is due to several causes, as for example, in the Bay of Fundy region to the extraordinary tides of that body of water and their erosive influence on the coasts, which furnish large quantities of material; in Northumberland Strait to the wear and waste of the land surface supplying abundant arenaceous and other materials to the rivers, streams, etc., which transport them seaward into the littoral of a low, shelving, sea border. It is in the Bay of Fundy region that salt marshes find their fullest development, while sand dunes, eel-grass and mussel-mud flats cover a much greater area in Northumberland Strait, and in the latter district especially, are all apparently of contemporaneous origin. The loose sands of the coast border in the latter region, moved about hither and thither as they are by marine currents, winds and waves, finally reach a comparatively stable position along these low sloping shores, where they are thrown down and form long beaches or dunes parallel to the coast-line with shallow lagoons of greater or less width intervening. While these materials are thus being shifted about in the littoral, a leaching out process is going on, due to the action of the sulphates of the sea water and the acids generated by the decomposing vegetable matter (peat bogs, grasses of salt marshes, etc.) of the coast margin. The lagoons within the beaches are really basins or vats where chemical changes in the ferruginous sands and silts are continually in progress, as these are carried down from the land by fluvial agencies. The bleaching of the sands composing the dunes therefore, while partly owing to mechanical attrition under flowing waters and to the surf; is principally due, perhaps, to the leaching out of the iron in them by decomposing humus. Beds of quicksand near the mouths of the several rivers emptying into Northumberland Strait seem now to be undergoing the purifying process referred to. Wells have been sunk in the dunes at a number of fishing stations, showing in decending order, (1) sand, (2) ferruginous gravel and rotted rock, and (3) gray Carboniferous sandstones *in situ*. The water in these wells is, of course,

Source of materials.

Leaching.

brackish and contains more or less ferruginous matter and other impurities, which have been developed from the chemical reactions alluded to. By these means and by continual attrition, the sands become bleached and whitened, especially in the upper layers of the dunes. The zone or belt in which these coastal deposits lie is of variable width, but they nevertheless form a definite series which, passing from the dry land seaward, may be classified as follows :—

Series of deposits of Recent Period on coast.

1. Salt marsh, bordered on the inner margin in some places by peat, in others by ferruginous sands, silts, clays, etc., the whole having usually a hard-pan beneath.

2. A shallow lagoon, channel or inner passage of the sea, in which tidal currents play backward and forward. This is really a basin or sink, into which the impurities of the land are drained and digested, and where chemical changes are continually in progress from the action of the sea-water and the organic acids brought from the land.

3. A broken strip of salt marsh lining the inner margin of the sand beach or dune.

4. The long, narrow beach of white or grayish-white silicious sands lying parallel to the coast, sometimes in one ridge, but where widest consisting of two or three. These are evidently wave-built and are often protected from denudation by a covering of coarse grasses and carices.

5. Shifting sand-flats in the littoral, wider or narrower according to the slope. Around Northumberland Strait these are of great width, and much of their surface is laid bare at ebb tides. Outside bars or sand ridges are thrown up, too, in most places parallel to those described, at whatever distance from the shore the waves first break during storms. That the material of these dunes and sand-bars is accumulating, seems proved from the fact that the latest or outside ridges are usually larger than the inner and are apparently, in some cases at least, increasing in width ; while between tide marks great quantities of loose sands lie ready to be shifted about or thrown up by the waves during heavy storms.

Beaches on Prince Edward Island.

The sand beaches on the north side of Prince Edward Island, are much the same in character and composition as those on the mainland. One of the largest of these, of which Hog Island forms a part, was examined with some care. Here the older or inner ridges of the beach were found to consist of reddish or partially oxidized sands, while those facing the Gulf of St. Lawrence and lately formed, or now in process of accumulation, had the usual whitish or bleached colour. From six to ten parallel ridges of sand were found in this beach, the latest formed being the highest. The width of this beach is from a

quarter to half a mile. Along the inner border of the beach are lagoons, bogs and marshes. Crystalline boulders were met with lying upon the surface of these salt marshes, though no evidences of glaciation were observed on the adjacent shores or islands, rotted rock being everywhere abundant.

The older ridges of the dune or beach referred to, are now clothed with stunted spruce trees and bushes of several species of hardwood, together with ericaceous plants. Those ridges lately formed, are covered merely with coarse grasses or carices.

Local Changes and Conditions of the Dunes.

Changes in the duues.

These shifting sands may be considered under two aspects at least, first, in reference to the navigation and silting up of the rivers and harbours, and secondly, in their relation to the agricultural character of the coastal districts.

Silting up of the harbours around Northumberland Strait.

Generally speaking, it may be stated that all the harbours around Northumberland Strait, *i. e.*, around the coast of the Carboniferous area of New Brunswick, Nova Scotia and Prince Edward Island are silting up. This is the result of two causes, first, the accumulation of material carried down by the rivers and streams and deposited in the estuaries, which may be called *fluviatile;* and secondly, the action of the sea in throwing back these loose sands into the mouths of the harbours and inlets. It is now well known that the sands which are shifted by winds, waves and currents into the mouths of the harbours at Bathurst, Miramichi, Richibucto, Summerside, etc., by heavy storms are a serious obstruction to their free navigation. To

How caused.

show how these sands accumulate, let us take the case of the Richibucto harbour, at the entrance to which a breakwater has been constructed. Beyond the outer end of the breakwater, the sands are thrown into the channel by heavy storms spring and fall. Dredges have been used to clear it out, but the river itself is a most effective agent in this regard, the sands thrown into it by the storms being thus cleared out, partially at least, by river freshets. These filling and clearing out processes continue year after year, and before the breakwater was built, caused a slight shifting of the channel periodically. This shifting or diversion of the channel was a movement away from the direction of the prevailing north-east winds which accompany the heaviest storms. At present, the channel or passage outside the breakwater only is subject to changes of this kind; but in 1890 I found it had been so far shifted as to throw it up against the southern dunes. When it reaches this stage and becomes choked up, the dredge has again to be brought into requisition, and a new and

straight channel cut directly from the end of the breakwater. High river freshets aid this operation materially, afterwards the operations of nature just described, of filling up and clearing out will be again repeated. This is one instance among a number which might be cited to show how these sands obstruct navigation.

In reference to their effect upon the agricultural character of the country bordering the sea, it may be stated that portions of it are almost valueless from the quantities of blown sands drifted over them, often to the depth of several inches. The leaching out, or deoxidation of the iron in these arenaceous strata, referred to on a previous page, also impoverishes the soil, rendering it of inferior agricultural value. Effect of sands on value of the land near coast.

Salt Marshes in Northumberland Strait.

The salt marshes of the coast of Northumberland Strait, are quite different from those of the Bay of Fundy, both in regard to their physical character and agricultural value. While the latter are built up mainly by the action of the great tidal wave of that body of water, those under consideration are invariably found in places which are protected from the denuding action of the sea by natural barriers of some kind. The materials of which they are formed may be characterized as silt, with coarse, gravelly, clayey and pebbly deposits of the nature of hard-pan beneath. These marshes are of much less depth than those of the Bay of Fundy, and are usually covered with a thick mat of the roots of coarse grasses and carices. The yield of hay on them is also less, and consists of several species of wild grass only, but does not include timothy (*Phleum pratense*), or upland grass. On the marshes which have been dyked, and from which hay has been cut for a number of years, a change in the species of grasses has taken place, the coarser kinds becoming replaced by those which grow in cultivated fields. The undyked marshes are partially overflowed annually by high autumn tides. The limited area of all these marshes, dyked and undyked, and their precarious and uncertain yield, render them of minor importance compared with the Bay of Fundy salt marshes. The largest salt marshes of this kind along Northumberland Strait, occur at Baie Verte, Shemogue, Aboushagan, at the mouths of the Richibucto, Kouchibouguac and Kouchibouguacis rivers, and in Prince Edward Island, at the head of Hillsborough Bay. Salt marshes in Northumberland Strait. Of limited area.

Bay of Fundy Salt Marshes.

The salt marshes of the upper part of the Bay of Fundy, have been formed under quite exceptional conditions, and although classed with Salt marshes of Bay of Fundy.

those of Northumberland Strait, they are really distinct in character. The great tidal wave of the Bay of Fundy has been the chief agent in producing them. These tides flowing at the rate of five or six miles an hour into the bays and estuaries, are loaded with reddish sediment which is everywhere deposited before they ebb. It is not uncommon for a single tide to lay down an inch or more in certain spots along the river banks. The soft Carboniferous shales around the head of the bay furnish, by their waste, the material necessary for marsh building. The force of the tides prevents the formation of any submarine, or eel-grass flats, such as occur in the shallow waters of Northumberland Strait, consequently at ebb tides, only bare, muddy slopes are to be seen. At high tides the creeks and inlets are filled to the grassy border, at low tides they are yawning, slimy gashes in the earth with tiny streams trickling in their bottoms. In whatever way the waters move, summer or winter, they are always loaded with reddish-gray sediment or mud, and run like a mill-race.

Materials of, how deposited

Area not increasing in historic times.

The area of these marshes does not seem, so far as observations extend, to be increasing seaward since they were first dyked, that is, within the last two hundred years; but it is stated that the estuaries are filling up and becoming narrower. There is a tradition among the old settlers in the Isthmus of Chignecto, that about the time Fort Beausejour (now called Fort Cumberland) was captured by the English in 1755, the Missaquash River was navigable for canoes nearly to its source; but this is not now the case.

Height of these salt marshes.

The salt marshes lie at the height of ordinary spring tides, and portions of them can be overflowed by opening the dykes. Very high tides, such as the one which accompanied the Saxby gale of October 5th, 1869, overflow them altogether. Along the banks of the rivers or estuaries, the land is a few feet higher than the inner or central portions of the marshes, owing to differential deposition of the sediment. The formation or building up of these marshes seems to have taken place coincidently with a slight subsidence of the land here in the recent period. This subsidence is proved by the existence of forest beds below the marsh mud, and, of course, below the level of the Bay of Fundy waters. The boring at Aulac station shown on page 129 M, illustrates this, and in the excavation for the western dock of the Chignecto marine railway the forest bed was found to be thirty feet below the level of the marsh or eight feet below mean tide level. Referring Sir J. W. Dawson's figures given for the level of stumps found *in situ* in this vicinity to mean tide, some are 10·80 feet below it and others only ·30.* At the public wharf at Edgett's Landing near

How built up, and when.

* Acadian Geology, Suppt. to 2nd ed., page 13.

Hillsboro', Albert county, in the mouth of the Petitcodiac estuary, a stump of a tree *in situ* was pointed out to me by J. B. Hegan. C.E., of the Public Works Department, St. John, and found to be 15·32 feet below mean tide level.

The following two sections, in descending order, exhibit the structure of the whole series of the superficial deposits at the Fort Lawrence dock. No. 1 was taken at the east end of the excavation where the marsh mud rests on the slope of Fort Lawrence ridge :— Section of salt marshes and underlying beds, No. 1.

1. Marsh mud, reddish, 2 feet 11 inches.
2. " bluish-gray, 9 inches.
3. " grayish, full of roots of plants and shrubs, 1 foot 8 inches.
4. " bluish, with roots, 2 feet 10 inches.
5. " dark-gray with bluish tint, full of roots and stems. (This corresponds with the forest bed and the overlying bluish fossiliferous clay in the west end of the excavation), 1 foot 8 inches. See section No. 2 below.)
6. Stratified, or partially stratified, gravel sand and clay containing water-worn pebbles, roots of shrubs and plants, etc., 1 foot 11 inches.
7. Boulder-clay, containing local boulders, some striated. Thickness not known; in excavation, about 40 feet.

No. 6 of this section is the most interesting. It is chiefly sand, and is either the boulder-clay changed under subærial action, or it is the representative of the Saxicava sand and Leda clay in the Isthmus of Chignecto, most probably the latter. A few pebbles of granite, etc., occur in it, but apparently only such as are derived from the Carboniferous conglomerate. Its depth beneath the surface of the marsh now is nine feet ten inches It seems to lie somewhat unevenly on the surface of the boulder-clay, and the strata are irregular. The character and position of this part of the series, therefore, denote a considerable interval of time between the deposition of the boulder-clay and that of the overlying marsh mud, during which the Leda clay and Saxicava sands were laid down along the coast borders elsewhere.

Section No. 2 at the south-west end of the excavation, which is only a few yards from the confluence of the La Planche and Missaquash rivers, exhibits the following series of beds :— Section No. 2.

1. Marsh-mud with roots and stems of herbaceous plants, grasses, etc., 12 to 15 feet.
2. Marsh-mud, stratified, gray, and containing marine shells, 5 to 10 feet.
3. Stratified, tough, blue clay containing an abundant molluscan fauna of the following species, *Macoma fusca*, *Mya arenaria*, *Rissoa minuta*, *Nassa obsoleta*, etc., 5 to 6 feet.
4. Peat and forest bed containing stumps and portions of the trunks of hacmatack, black spruce, birch (probably *Betula lutea*) alder, poplar, hemlock, elm, ash, etc. (one stump of hacmatack being 12 to 15 inches in diameter), 1 to 2 feet.
5. Coarse, gravelly, oxidized, reddish-blue clay, partially stratified at summit, resembling the lower part of the Leda clay, but changing into true boulder-clay

below. It contains boulders of sandstone of local origin. Thickness variable, but not exceeding 1 foot

6. Boulder-clay, containing numerous boulders of local rocks, of all sizes, up to 3 feet in diameter, some of them glaciated. Thickness unknown; it probably extends below the waters of Cumberland Basin.

Forest bed under marsh mud.

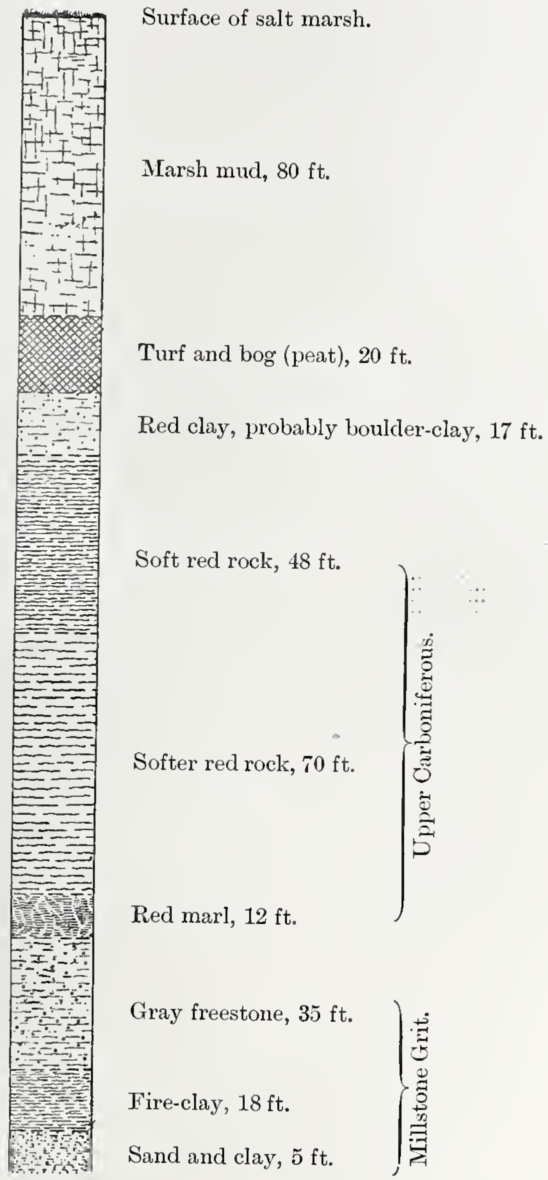
The length of the excavation for this dock is about 300 feet, and the total depth below the surface of the marsh between fifty and sixty (53 feet). The forest bed slopes towards Cumberland Basin about twenty feet within the length of the excavation (300 feet), that is, eight-tenths of an inch per foot, and lies thirty feet below the surface of the marsh at the western end of the excavation, as stated above.

Another section of the salt marsh, with the underlying forest bed, was disclosed in the boring at Aulac station, Intercolonial railway, and is represented on page 129 M by diagram No. I. This section shows the maximum thickness of the marsh mud and forest bed here, the bottom of the former being fifty-nine feet below mean tide level, and the peat or forest bed, which is twenty feet in thickness, lying from fifty-nine to seventy-nine feet below the same datum. This marsh (Tantramar and Aulac) covers an area of not less than sixty square miles, thus showing a large accumulation of material here in the recent period.

Geological conditions of deposition.

Regarding the conditions under which these materials were deposited, it would appear that the marsh mud belongs mainly to a period of subsidence, as already stated, in the early stages of which there must have been an interval of quiet in this part of the Bay of Fundy. The strata of fine blue clay and the well preserved condition of the contained fossils, show that they could not have been thus deposited if they were within the range of the heavy sweeping tides transporting sediment, such as exist at the present day. The shells belong to shallow water species, and it really seems as if the turbid condition of the waters in the upper part of the Bay of Fundy and the extraordinary tides did not exist at that time. It is, therefore, probable that the fossiliferous deposit in question was laid down in a quiet lagoon or recess to which the strong ebb and flow currents, if they existed then in the bay, had no access. There is, however, no abrupt line of separation between the blue fossiliferous clay and the overlying marsh-mud, and the fossils are found to extend locally, but in diminishing numbers, upwards into the lower strata of the latter, disappearing entirely in the uppermost portions. *Macoma fusca* is still met with on the shores of the upper part of the Bay of Fundy in some places, while this and *Mya arenaria* and *Nassa obsoleta* are common in Baie Verte in Northumberland Strait.

Fauna.



SECTION OF THE STRATA AT AULAC, INTERCOLONIAL RAILWAY, PASSED THROUGH IN A BORING MADE UNDER THE DIRECTION OF P. S. ARCHIBALD, CHIEF ENGINEER, I. C. R.

Salt marshes formed during subsidence.

The depth and extent of the marsh deposits indicate that their formation must have extended over a considerable time. This view is compatible with the fact that their accumulation and increase in height or thickness would be coincident with the sinking of the land, which took place in the region since the peat and forest beds grew. Whether these marshes, if now in a state of nature, would be still receiving additions upon their surfaces sufficient to raise their level higher, is a question referred to below. The condition of the older dykes around them and other facts bearing upon the question of a change of level, rather support the conclusion that the land is now nearly stationary.*

Forest Bed Under Salt Marshes.

Forest bed under salt marshes; how it grew.

In regard to the forest bed referred to, it would seem, from a number of facts collected in different parts of the salt marsh area, as well as from the presence of shallow peat bogs along its junction with the uplands, that peaty matter has been continually growing on the inner borders of these marshes ever since they began to accumulate. As the land subsided and the salt marshes accumulated, keeping pace therewith, these peaty margins likewise flourished wherever the drainage or fresh water from the adjacent uplands became stagnant and other conditions favourable to their growth existed. These inner margins of the marshes are rather below the general level of their surface, hence the formation of shallow lakes skirted with peat bogs is a necessary result. From these circumstances, it would seem that peat, or forest beds, may be found continuously at the junction of the marshes with the sloping uplands, from the bottom to the surface. Mr. Alex. Munro, C.E., of Port Elgin, New Brunswick, first drew my attention to this fact.

Chemical changes in materials of salt marshes.

The original material forming the salt marshes has probably, in all cases, been a red loam or mud, a product of the marine and subaerial action which decomposes the soft red Carboniferous sandstones of the region. It appears, however, that the red colour is liable to be changed into gray, in at least some portions of the marshes. This change is brought about by the chemical alteration of the iron oxides into sulphides by the sea water, or by the action of the organic acids on the iron contained in the marsh mud.† We find, therefore, that the inner portions of the marshes consist almost wholly of gray or bluish-gray material, with more or less vegetable matter disseminated, while the outer portions or those exposed to the tidal currents

*Ann. Report, vol. IV. (N.S.) 1888-89, p. 74 N.

†Acadian Geology, 2nd ed., p. 24.

are red. Cultivation, draining and aerating the upper strata, it is said, change the blue mud into red, *i. e.*, the iron compounds become changed from sulphides into oxides.

The blue and red muds often occur in alternate layers, where the tides have been allowed to overflow the marshes periodically. At Sackville the following section of the beds was observed, the series being descending :— Blue and red mud.

1. Red marsh mud.
2. Peaty matter or humus, graduating into blue clay in places.
3. Red mud or clay, changing into blue clay.

These strata lie under an undrained field, the peaty covering of former surfaces having been overflowed on two occasions, and red sediment deposited. There appears to be a general tendency for the marsh mud to change from red to blue, as above stated, where the marsh is low and flat, and where the precipitation is apt to lie upon it, and the sea is prevented from overflowing. The gray or blue marsh, has, in wet places, a tendency to become covered with a growth of peaty matter and shrubbery.

Agricultural Character of the Salt Marshes.

The chief portions of all the larger marshes are dyked, but additions of greater or less extent are constantly being made to some of them. Where the dykes are kept in good order, the marshes are almost as dry as the adjacent uplands. They have long been noted for their great fertility. Hay has been raised on them for one hundred and fifty years or more without the application of manure, and they also yield cereals and root crops abundantly. The soil of the older dyked and cultivated marshes is, however, deteriorating, owing to continual cropping; and those portions of them which have not been overflowed by the tides for many years, are now well nigh exhausted, so far at least as regards the production of hay and cereals. They require, therefore, new and different methods of culture from those hitherto employed. Agricultural character.

In the report on Government Experimental Farms for 1890, Mr. F. T. Shutt, chemist, gives analyses of two samples of soils from the Sackville marshes, among those from a number from other localities, and offers some pertinent advice in regard to their improvement, recommending lime, wood ashes, etc. Subsoil ploughing, draining and the application of the fertilizers recommended by Mr. Shutt, as well as barn-yard manure, would all doubtless be highly beneficial, but I am informed that it has been found by experience that the results of this method of tillage are not commensurate with the cost and labour expended, and that the improvement of such large areas of marsh lands as these Methods of improvement.

would be too slowly reached in this way. A scheme inaugurated by the more intelligent farmers of Sackville, seems to afford at once a more efficaceous and economic mode of fertilizing these lands, and promises to bring about important changes in their culture. This is nothing more than flooding them for a year or two by the sea. Where it has been tried, the results have been found highly beneficial. The *modus operandi* is to cut away certain portions of the dykes and open the *aboideaux* (exit gates of the fresh-water streams), allowing the sea to enter and spread a deposit or layer of red sediment over the surface of the marshes, and after sufficient material has thus been deposited then to close the *aboideaux* and dykes and permit the land to dry for a season or two. During the first year after this treatment, only the coarser kinds of grass, chiefly *Spartina stricta* or *alterniflora*, commonly called "broad leaf," grow, but the second or third year the marsh resumes its former covering of meadow grasses and continues for many years afterwards to yield an abundant crop without further cultivation. All this has already been proved by actual experiment, and the fact established that the red marsh sediment deposited by the tides acts as a natural fertilizer. Marsh owners who have thus allowed the tides to overflow their land at intervals have maintained the original productiveness of this kind of soil, in a large measure unimpaired.

Reclamation of swampy marshes.

The reclamation of peaty or swampy marshes lying along the junction of these with the uplands, especially as regards the Tantramar or Sackville marsh, is a work which has been in progress for years, with highly satisfactory results. The process consists first in draining and building *aboideaux* and dykes. The tidal wave with its burden of red mud is then admitted, and a layer from six inches to two or three feet deep deposited. The first year after reclaiming it, the product is chiefly "broadleaf," but afterwards as the salt becomes washed out of the sediment by atmospheric action and the upper strata aerated, the common grasses flourish most luxuriantly.

This mode of reclaiming the newer portions of the boggy salt marshes, and improving those impoverished or worn out by continual cropping, is now being carefully studied by the more intelligent marsh owners, and the result will doubtless be the adoption of practical and systematic methods tending to increase their productiveness. The method just outlined is, so far, considered the cheapest and best, and, indeed, nature's own method of restoring them in a large measure to their original condition of fertility.

Area of salt marshes at

The area of salt marsh around the head of the Bay of Fundy, on the New Brunswick side of the provincial boundary, as ascertained from a

careful computation, is about 34,300 acres. These figures include of course, the dyked and undyked marshes; the latter are, however, of small extent, and are merely fringes of the dyked and cultivated portions. Of this whole marsh area, Westmoreland county includes 25,200 acres, and Albert, 9,100 acres. The principal localities of the marshes referred to are along the Missaquash, Aulac and Tantramar rivers in Cumberland Basin, and the Memramcook, Petitcodiac and Shepody River valleys in Shepody Bay. The largest and most important of these is the Tantramar and Aulac marsh; it is also in the highest state of cultivation. head of Bay of Fundy in New Brunswick.

Considerable areas of marsh land have been allowed to go to waste from the breaking down of dykes, the owners, either from want of means, or other causes, permitting them, for want of repairs, to remain in a condition in which the marshes are subject to continual overflow by the tides. These, with the undyked portions might, with the expenditure of some capital, be readily brought under cultivation again and converted into good arable marsh.

Marshes not utilized to best advantage.

The Bay of Fundy marshes, notwithstanding their high value, are not utilized to the best advantage. If better methods of culture were adopted, their productiveness might, in large portions, be doubled. Imperfect draining, continual cropping without manure, allowing portions of them to grow up with weeds and shrubs, are the chief causes tending to their deterioration. The leading agriculturists are, however, becoming cognizant of the fact that their fertility has lessened, and will continue decreasing under existing methods of culture. Hence the reclamation of new or uncultivated portions, and the devising of means for increasing the fertility of the older dyked marshes.

The area of salt marsh bordering Northumberland Strait has not been computed, but it is limited, as already explained.

Natural Dykes.

Natural dykes, their appearance.

Along the estuarine parts of some of the streams falling into Northumberland Strait, notably Shemogue, Baie Verte, etc., occur certain formations called natural dykes, or sometimes "shooting dykes." The most noteworthy examples of the kind observed, are on a stream about two miles north of Port Elgin, called Timber Brook. Here they rise in definite ridges from three to five feet above the surface of the marsh skirting the stream, and continue without interruption for distances of a quarter or half a mile. Trees from six to nine inches in diameter are found growing upon them. The largest dykes occur upon the marshes bordering the estuary, but others are ranged along the base of the ascending slope of drier ground.

Materials. The materials of which these dykes are composed is altogether local. Along a dry bank they are gravelly or sandy, as the case may be, similar to the materials of the bank itself. On a marsh they are made up of marsh mud, with whatever other débris occurs in this. Newer portions of the dykes were observed to be in process of construction.

How formed. A careful study of these dykes will show that they must have been formed by the ice which forms on the estuaries of these streams every winter. This ice when grounding on the marshes or shores bordering the estuaries, by its expansion and shove moves portions of the material towards the banks, or away from the centre of the stream This process goes on year after year and is still in operation, and the dykes are thus formed by gradual and successive increments of material. Where the estuary is widest and the ice has the greatest expansion and room for movement they are highest, and if the locality is favourable a dyke will be found on both sides of the estuary. In certain cases the shove of ice-jams from the bay may have assisted in their formation. This explanation applies to all the natural dykes observed on both sides of Northumberland Strait. They are, therefore, of *recent glacial origin.*

Mussel mud.

Mussel mud, where found. Mussel mud is an estuarine silt, containing great quantities of oyster, mussel and clam shells, the first usually predominating, which occurs in the bogs and estuaries around Northumberland Strait, and at the mouth of the Baie des Chaleurs. Considerable quantities are taken up by dredging and applied to the land by farmers both on the mainland and on Prince Edward Island; but a much more extensive use of it might be made than has yet been attempted, with beneficial effect. Pulverizing and mixing it with barn-yard manure before spreading it over the land, causes it to assimilate more readily with the soil and thus reduces it to a condition in which it becomes more available for plant food. The mussel beds are often deep and furnish an almost inexhaustible supply of this valuable fertilizer. It is especially suitable for the soils resting upon the Carboniferous rocks, which are nearly devoid of lime.

Materials of. Although known by the name of "Mussel mud" from the presence of the shells of the mussel (*Mytilus edulis*) in the deposits, the designation of *Oyster mud* would really be more applicable, since the shells of the oyster (*Ostrea Virginiana*) predominate. Clam shells (*Mya arenaria*) are also found in it. These are all packed in a paste of mud, sand, etc., containing other organic débris. The whole deposit,

as shown by Sir J. W. Dawson, is a formation of the recent period.* Samples of mussel mud from New Brunswick and Prince Edward Island, analysed by Prof. F. T. Shutt, chemist of the Central Experimental Farm, Ottawa,† show that the amount of nitrogen, the chief fertilizing agent in their composition, is small. Its chief value for agricultural purposes is owing to the quantity of lime it contains. The fertilizing value is increased when it is composted with barnyard manure, peat, swamp muck, etc.

Agricultural value.

Agricultural Character of the Region.

Agricultural character of the region.

A large portion of the areas whose surface geology has been discussed in this report, is noted for its valuable agricultural resources. Cumberland county, Nova Scotia, Westmoreland county and the coast district of Kent county, New Brunswick, and Prince Edward Island, have long been remarkable for their excellent farms and the advanced methods of cultivating them.

In general it may be stated, especially as regards the eastern maritime provinces, that those portions of the coast districts on which marine sediments lie are the most valuable to the agriculturist. This arises from the fact that the materials of these sediments have undergone greater comminution in many places from the action of the sea, during the post-glacial subsidence of the land, and also because the deposits are, as a rule, deeper there than upon the higher grounds. There is likewise a greater commingling of organic matter with these soils. Moreover, the facilities for obtaining manures, such as sea weeds, mussel mud, fish offal, etc., for fertilizing the land, are much greater there than in settlements remote from the coast, thus enabling the practical farmer to keep the soil in a higher state of cultivation.

Most valuable soils.

Classification of the soils.

The agricultural capabilities of those portions of New Brunswick included in this report were treated in my preliminary report on the Surface Geology of the province, and a classification of the soils and sub-soils attempted.‡ In a subsequent report, a further classification of the soils was made into (*a*) sedentary, *i. e.*, those formed *in situ* from the disintegration of the underlying rocks, and (*b*) transported soils, or such as have been removed from the rocks to which they belong by glacial, marine, fluviatile or lacustrine action and deposited in new localities.§ The latter prevail in the coast districts of the maritime provinces, and cover large areas adjoining Northumberland

*Supplement to 2nd ed. Acadian Geology, page 17.

†Reports on Experimental Farms for 1890 and 1891.

‡Annual Report, Geol. Surv. of Canada, vol. I. (N.S.), 1885, p. 52 GG.

§Annual Report, Geol. Surv. of Canada, vol. IV. (N.S.), 1888-89, p. 76 N.

Strait and the upper part of the Bay of Fundy. The agricultural character of those portions occupied with salt marshes and recent sand formations has already been described on pages 131 M and 124 M.

Culture of soi in New Brunswick.

Commencing in New Brunswick, we may first note the value and condition of culture of the soils in the coast districts of Kent, Westmoreland and Albert counties.

In Kent County.

In Kent county, the narrow belts cleared along the coast and at the mouths of rivers, are, in some places, covered with blown sand, while in others, swamps and peat bogs prevail. This is especially the case north of Richibucto River. South of that, however, some good farming lands occur on the borders of Northumberland Strait, at Buctouche, Cocagne, etc. Excellent soils are found along the river-valleys, where the slopes are sufficient to allow the drainage waters to escape into the nearest rivers, and where there is always a greater or less breadth of alluvial deposits. But on the flat grounds which lie between the estuaries, notably between the Richibucto and Buctouche, and between the latter and Cocagne rivers, etc., there are also many good farming tracts occupied by a deep, rich, fertile soil.

In Westmoreland County.

The Isthmus of Chignecto contains probably the best farming lands in Westmoreland county, although some parts are sandy and others dry and stony. At Shemogue, Bay Verte, and on the Cape Tormentine peninsula—districts which have long been settled—there are large clearings and well cultivated farms; but those exhibiting the highest degree of culture, and where the occupants seem to be in the best circumstances, are around the head of the Bay of Fundy. On Westmoreland Ridge, at Aulac, Midgic, Sackville and other places around Cumberland Basin, where many of the farmers have a number of acres of salt marsh to the front of, or near their uplands, the condition and yield are very much in advance of the cultivated lands of any part of the country. The same observation applies to the agricultural condition of the districts in the Memramcook and Petitcodiac valleys. Large herds of cattle are raised in this part of Westmoreland, owing to the great yield of hay afforded by the salt marshes, and most of the farmers are in very comfortable circumstances.

In Albert County.

In the eastern part of Albert county, the areas of low land along the coast are narrow in most places, and form mere selvages. At Harvey and New Horton, however, the Lower Carboniferous rocks do not form such a broken country as further to the north, and here we find a considerable area of good farming lands. Benches, or marginal strips of excellent soil, skirt the coast of Shepody Bay and the estuary of the Petitcodiac River, overlooking the salt marshes. The latter, while of considerable extent on both sides of Shepody River and else-

where, are not utilized to the best advantage. The dykes in many places have been allowed to go out of repair, and portions of the marshes are, consequently, subject to overflow by the tides. Too heavy cropping also, without the application of any fertilizing material, is another evil. In consequence of this, large portions of these marshes have turned into what is known as *blue marsh*, a wet, spongy, fetid formation, and are unproductive. Improved methods of culture, such as have been inaugurated by the marsh owners at Sackville, are required. Despite these things many of the farmers in eastern Albert are in good circumstances, and form intelligent, industrious communities.

Cumberland county, Nova Scotia, comprises as large and thriving a body of farmers as are to be found in any part of the maritime provinces. The slope facing Northumberland Strait is well situated as regards drainage, and the soil, derived as it is mainly from the Upper Carboniferous sediments, is deep, rich and easily cultivated. In the settlements along the coast there are many excellent farms in a high state of cultivation. Cumberland County, N.S.

At Amherst, Nappan, and in the area drained by the Maccan River, several good agricultural tracts border the salt marshes, and upon the slope there are fine, loamy, arable soils. The Branch Experimental Farm at Nappan, under charge of Col. Blair, is an example. The methods of culture employed there, show what can be done on the farms of the maritime provinces, and the kinds of crops that thrive best.

Upon the higher grounds of Kent, Westmoreland and Albert counties, New Brunswick, and Cumberland county, Nova Scotia, we meet with different soils, and in many cases poorer farms, and consequently less advanced methods of cultivating them. Yet in a number of places in the region the uplands really form excellent soil, and where the drainage is good, they are not inferior to that of the coast districts. Upon the Middle Carboniferous of Kent and portions of Westmoreland counties, however, the surface is flat and the drainage deficient; hence the soils are cold, boggy, and in many places covered with a stratum of white or gray bleached sand, under a veneering of vegetable growth. Upon the rolling surfaces, however, there are, as already stated, fair arable soils, though deficient in lime. Along the Richibucto, Buctouche and Cocagne rivers, at St. Anthony settlement, in Kent; and at Irishtown and other places in Westmoreland, the agricultural conditions last referred to are exemplified. Soils of the higher portions of the region.

In Cumberland County, Nova Scotia, above the limits of the post-glacial subsidence, we meet with soils and rocks differing somewhat from those of the Middle Carboniferous just described. Here the prevailing surface beds are reddish in colour, being derived either from the Upper

or Lower Carboniferous sediments, or from both. The soils are, therefore, lighter, and as a rule, more porous and easily cultivated. The surface is, generally speaking, rolling, and consequently the drainage is better. On these uplands there are many tracts of good land with excellent farms upon them, especially on the slope between the Cobequid Mountains and Northumberland Strait. Certain undrained sandy tracts are barren and remain uncleared. Some of the higher grounds are occupied with boulder-clay, but these when well drained form rich heavy soils. Here, as in New Brunswick, there is a deficiency of lime in the soil, except where the Lower Carboniferous limestones prevail, and they all seem to be largely benefited by plentiful applications of this fertilizing material, as well as by mussel mud and gypsum.

Prince Edward Island.

Prince Edward Island, which is probably the best agricultural portion of the maritime provinces, taken as a whole, contains less waste land in proportion to its area than either Nova Scotia or New Brunswick. The soil is derived almost wholly from the disintegrated Upper or Permo-Carboniferous sandstones and Triassic beds which occupy the island, and is therefore largely indigenous. On the higher grounds, it consists mainly of rotten rock *in situ* with a veneering of stratified material due to the atmospheric and fluviatile agencies which have affected them; while along the coast, boulder-clay, in places capped with marine deposits, generally prevails. It is therefore, usually light, porous, easily cultivated, and well adapted to the production of oats and root crops. Like the soils resting upon the Carboniferous rocks of New Brunswick and Nova Scotia, it is deficient in lime. The farmers of this island fully recognize this deficiency, however, and have been utilizing the extensive deposits of mussel mud which lie in the harbours and creeks. Certain localities where good farms were observed might be particularized, but, in general, it may be stated that the part of Prince Edward Island now in the highest state of culture is that lying near Richmond and Hillsborough bays, especially along both the north-east and south-west coasts. The higher central part does not contain so much good arable land, nor do the districts north of Richmond Bay and east of Hillsborough Bay, though there are many excellent farming tracts in these also.

The agricultural character of Prince Edward Island has been discussed by Sir J. W. Dawson,* who speaks of its fertile soil as a source of great wealth to the inhabitants. In this connection, however, the great facilities for obtaining fertilizers have to be borne in mind. In nearly every bay and estuary, extensive deposits of mussel mud occur.

Fertilizers in P. E. Island.

* The Geological Structure and Mineral Resources of Prince Edward Island. By Sir J. W. Dawson and Dr. B. J. Harrington, 1871.

In addition to this valuable fertilizing material, peat, marsh and swamp muck, seaweeds, fish offal, etc., are extensively employed. When these are composted with the mussel mud a rich manure is produced, which can either be ploughed under and used for root crops or utilized as a top-dressing on the land. The fertilizers mentioned exist in almost inexhaustable quantities on Prince Edward Island, and are accessible to nearly every farmer.

FORESTS.

The forests of the region included in sheets No. 2 S.E., 4 N.W. and 5 S.W. present some features worthy of consideration as regards the local distribution of the different kinds of trees which grow therein. In the area bordering Northumberland Strait, the sylvan growth is of a mixed character, with a predominance of the coniferæ. The indigenous trees of economic importance are pine *(Pinus Strobus, P. resinosa* and *P. Banksiana)*, spruce *(Picea alba, P. nigra* and *P. nigra* var. *rubra)*, fir *(Abies balsamea)*, hemlock *(Tsuga Canadensis)*, cedar *(Thuya occidentalis)*, hacmatack *(Larix Americana)*, and the deciduous trees, birch *(Betula lenta, B. alba* var. *populifolia, B. papyracea* and *B. lutea)*, maple *(Acer Pennsylvanicum, A. saccharinum, A. rubrum* and *A. spicatum)*, poplar *(Populus tremuloides, P. grandidentata* and *P. balsamifera)*, beech *(Fagus ferruginea)*, ash *(Fraxinus Americanus* and *F. pubescens)*, elm *(Ulmus Americanus)*, oak *(Quercus rubra)*, etc. Besides these there are a variety of native shrubs, some of which, in more southern latitudes, grow to the size of trees, but here, owing to the severe climate of the coasts, become dwarfed. Even the larger trees, strictly indigenous to the country, are found, on approaching the coast, to exhibit striking differences and peculiarities, the more noticeable of which are the prevalence of the coniferæ on the lower grounds, over which winds and fogs from the ocean pass without obstruction, and secondly their shorter and more spreading and stunted size. The prevalence of small black spruce, hacmatack, cedar, white birch and the various shrubs of the country upon the region bordering Northumberland Strait is a characteristic feature. These sylvan forms, together with the occurrence of heavy peat bogs upon the low grounds of the Carboniferous area, show that a certain zone or belt bordering the sea is, to some extent, unfavourable to the development of the large forest trees. In sheltered spots, however, as, for example, upon the Cobequid Mountains and the crystalline plateau of southern New Brunswick, the hill ranges afford protection from the winds and cool vapours coming from the ocean, and a large growth of both coniferous and hardwood trees is found.

Forests.

Species of trees.

Character near the coasts

Character, inland.

Proceeding inward from the coast, a much greater diversity in the distribution of the forest trees is found. This distribution is evidently affected by several causes, (1) by the elevation, or rather by the protection afforded by ridges and mountains from bleak winds and storms and from the sea air of the coast districts, (2) by the aridity or wetness of the soil, viz., its condition as to drainage, (3) by the physical character of the soil, viz., whether clayey, gravelly, sandy or loamy, and (4) by the mineral composition, in other words the character of the underlying rock-formation, whether calcareous, silicious or otherwise.

Causes of difference.

Effects of soil or rock formations on forest growth.

The relation between the soil, or the rock-formations, and the vegetable growth upon it, is in northern climates, such as the maritime provinces of Canada, difficult, if not impossible to trace; nevertheless, it is observed that certain geological formations are more favourable to the production of certain kinds of trees than others. Calcareous soils, for example, nourish the heaviest growth of both hardwoods and conifers. In New Brunswick, as indeed, in all glaciated countries, however, we cannot determine the exact limits of the areas of the forest growth affected by the geological formations. On the hills and ridges underlain by limestones, we meet with maple and birch groves, intermixed occasionally with spruce. The Cambro-Silurian and the old crystalline belts of rocks traversing the province from the Baie des Chaleurs to the Chiputnecticook Lakes, seem also to mark a boundary in the forest distribution. North of this lies the great area of Silurian limestones, south of it the Carboniferous sandstones. Owing to the larger extent of country which these formations occupy, the soil necessarily bears a closer relation to the underlying rock, and is less intermixed with extra-limital drift; consequently the vegetation and forest growth upon these areas ought to show the effect of each particular kind of soil upon the flora of the country. Have these districts any peculiar forms in their floral productions?

Upon Silurian limestones.

On the Silurian limestones there is observable a paucity of ericaceous plants, of scrub pine and black spruce, and an almost entire absence of hemlock, all of which are abundant on the Carboniferous sandstones, the latter tree, indeed, reaching fuller development on these as regards size and number than elsewhere in the province. White spruce, fir, white pine, the paper birch, and beech appear also to be more abundant upon the Carboniferous area, though common also upon the Silurian uplands. But the striking features of the forests upon the latter are the groves and ridges of birch and maple occuring in almost every part. These are seldom met with on the sandstones except where Lower Carboniferous limestones prevail.

The comparative abundance of ericaceous plants on the Carboniferous areas is doubtless due, in some measure, to the flat surface and consequent imperfect drainage, resulting in the formation of swamps, peat bogs, etc., where these forms of vegetation find a congenial habitat. But the difference in the sylvan growth occupying the drier grounds of the two regions in question is not explicable unless we admit that the geological formation has an influence upon it. On the sandstone area, the hemlock and scrub pine are most abundant trees compared with their distribution upon the Silurian uplands. Black birch, beech, and black spruce also appear to be more common and larger. These facts regarding distribution lead to the inference that the gravelly, silicious soil overlying the sandstones is more favourable to the growth of these trees, or it may be that the limestones are unfavourable, or, perhaps, both causes operate. Upon Carboniferous sandstones.

In regard to the hemlock (*Tsuga Canadensis*) it was pointed out in a previous report* that the distribution of this tree is peculiarly restricted from some cause or causes. Nearly all hemlock trees are found to have attained their full growth. Young or growing trees were observed only in a few localities, especially along Nashwaak and Little Southwest Miramichi rivers. In areas where it has been destroyed it does not grow again like spruce, fir, cedar, hacmatack, etc. These facts indicate that the existence of the hemlock tree in this region is on the wane. All the other forest trees will grow up and replenish the region once more except where it has been overrun by fires. Is the cause of the decadence of the hemlock climatological, *i.e.*, due to recent changes in the mean annual temperature, rainfall, etc.; or to the destruction of the surrounding forests? No satisfactory answer can be given to this question. Hemlock.

The black spruce, which is a tree of the greatest economic value, does not now seem to be so thriving and vigorous as its congener, the white spruce; and the cedar (*Thuya occidentalis*), though common in New Brunswick in all moist low grounds, and also met with not uncommonly in Prince Edward Island, is a tree also restricted in its range, occurring only very sparingly, if at all, in the peninsula of Nova Scotia. Black spruce. Cedar.

The forests in New Brunswick, and, indeed, throughout the Canadian maritime provinces, are undergoing rapid destruction. When the Loyalists landed at the mouth of the St. John River on the 18th of May, 1783, the New Brunswick forest stood almost untouched in all its pristine grandeur, now the original growth has been largely cut Destruction of forests.

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*Report of Progress, Geol. Surv. Can., 1882-83-84. Part GG.

away, the coniferæ, especially, having suffered depletion in almost every accessible locality. Only in some parts of the region drained by the Restigouche, and in other remote places, does the original forest growth still remain intact. The old sturdy pines, monarchs of the New Brunswick forest, were the first to suffer. In the days of pioneer lumbering operations, these were felled and one or two pieces of square timber made from each trunk—the remainder of the tree was left to rot. These pines are all gone. The spruce has next been attacked, and since the inauguration of the modern steam saw-mill, the manufacture and shipment of spruce deals to the British market, have together become a large and important industry. The prosecution of this business has, however, brought about a rapid demolition of the spruce forests throughout the province. In some of these depleted areas, *i.e.*, where the larger trees have been cut away, a younger growth is taking its place, however, and as the white spruce grows rapidly, the original forest growth might be replenished in this way, if fires did not overrun the country. Lumbermen state that unless too heavy a cutting is made, the same tract can be re-cut for spruce logs every ten or twelve years, owing to the rapidity of the growth of the white spruce.

How brought about.

Destruction of hemlock.

The hemlock tree is now being subjected to destructive processes also, and is very likely at no distant date to be altogether exterminated. Within the last twenty years, important industries have sprung up in different parts of New Brunswick based upon the use of the hemlock bark for tanning, and large quantities of tanning extract have been prepared for export. To obtain the necessary supply of hemlock bark to carry on this business, the trees are cut down and the bark peeled off, the trunk and branches often being left lying in the woods. Near settlements, some of these trunks are utilized in the manufacture of scantling, boards, etc., and hemlock timber is commonly used for the building of wooden bridges, wharfs and breakwaters, as it is found, when placed under water, to be slow in rotting. But large numbers of these felled trees are not used in any way, and after a time, when their branches become dry, they serve as fuel for forest fires. The destruction of this tree from the last cause is tenfold greater than from all others combined.

Of the cedar.

An extensive industry has within the last decade arisen in the maritime provinces from the uses for which cedar is required. Previous to that date the trunks of the cedar trees were used only, to a limited extent, for foundations to buildings, for telegraph poles, fencing and the manufacture of shingles. But within the period mentioned cedar has come greatly into use for railway ties and fence posts, and the shingle industry has also expanded to enormous dimensions, though it has

latterly suffered a reverse owing to over-production. The principal market for cedar wood is in the United States.

The impetus given to the cutting and export of cedar in New Brunswick is also leading to the exhaustion of this tree, and already whole river basins have become well nigh depleted of cedars. As it is a tree which grows very slowly, there will, in all probability, be a scarcity of cedar in the maritime provinces in less than a quarter of a century, if the present methods are continued.

Areas over-run by fires.

From the foregoing statement of facts, it will be seen that very great inroads are now being made on the original forest growth of the maritime provinces. The destruction or depletion by legitimate means, that is, from the ordinary lumbering operations of the country is, however, not exhaustive, but such as could, doubtless, be checked or regulated with a view of conserving the forest. That going on every year from forest fires is vast in proportion and far-reaching in its effects. No regulation seems at present competent to control this evil. Since the great Miramichi fire of the 7th of October, 1825, forest conflagrations have been of constant and almost annual occurrence. The dry, gravelly and sandy areas, underlain by Carboniferous and granitic rocks, have suffered most. Along the Southwest Miramichi River and its tributaries, a large portion of the district occupied by Carboniferous rocks has been overrun by fires, part of it in 1825, at the time of the great fire above mentioned, and part of it at a subsequent date. A second growth of trees now covers some portions of these areas, but this also has, in certain sections, been destroyed by recent fires. Large portions of the country lying between the Southwest Miramichi and Salmon rivers, and the head of the Richibucto River have likewise been devastated in this way.

Along the Intercolonial railway between Moncton and Bathurst, forest fires occur in the woods on both sides of the line at irregular intervals almost every summer, and have thus destroyed the timber over large areas. When this railway was constructed about twenty-five years ago, it passed through virgin forest for two hundred miles of the two hundred and twenty-two between Moncton and Bathurst. The opening of new settlements since that date, the lumbering operations carried on along both sides of the route, and the cutting down of the hemlock for tan-bark, etc., have brought about nearly a total demolition of the original forest adjacent to the railway. After every dry season there is a fire, originating no one seems to know how, and few seem to care, if not personally affected by it. It must be confessed, however, that farmers in clearing up new land, woodsmen, hunters, and fishermen are not careful enough in preventing the spread of fire. The forest is

largely coniferous, therefore in dry weather especially combustible, and when fanned by a breeze any fire soon spreads beyond control.*

Difficulties of protecting the forests from fires.

No protection has yet been exercised to guard against these public calamities further than the enactment of a statute, prohibiting under a penalty, the setting of fires at certain seasons of the year; but the expense of properly enforcing this would be beyond the means of the country. Carelessness prevails, therefore, on all sides, and no one takes much interest in the preservation of the forests from a national point of view, or unless it is of some direct benefit to himself. Indeed, it is practically impossible to devise methods of preserving them, owing to the lack of public interest in the matter, and it seems not at all unlikely that the existing condition of things will continue until they are wholly destroyed. Then, and not till then, will the people begin to realize their value.

Rate of the growth in the eastern provinces.

The rate at which a tree grows in the forests of the eastern maritime provinces, is a question sometimes discussed by practical lumbermen in view of forest conservation. Since the cutting down of trees of commercial value below a minimum size or girth is prohibited by law, it follows, that if they are protected till they attain the standard size, this periodical replenishment might be the means of preserving them from total destruction, excepting, of course, the ravages of forest fires. The question then arises, how long does it take a tree such as, for example, the black or white spruce, or the white pine, to attain a certain size; and, having attained a size of say fifteen inches in diameter above the roots in a given number of years, how long would it take it then to reach a diameter of say twenty or twenty-four inches, in other words what is the annual growth of our forest trees in youth and at maturity? No observations have yet been made which enable us to give a definite answer to these questions. There is, however, one locality in New Brunswick, that of the Miramichi fire of 1825, which, from the fact that it is now covered with a young forest grown up since that date, affords a criterion of tree growth upon a given geological formation, viz., the Carboniferous sandstones. But it does not show what the rate is when trees arrive at a diameter of fifteen inches and upwards. It affords data, however, showing the comparative rate of growth of different species during the period mentioned. For example, poplar (*Populus tremuloides*) was found with a girth of fifty-one inches above the roots; white spruce (*Picea alba*), fifty-four inches; black spruce (*P. nigra*), forty-eight inches; fir (*Abies balsamea*), forty inches; red

Growth and size of some species found upon the area of the Miramichi fire.

*It would seem that this region must have been subject to forest fires before the settlement of the country by the white man, if we may judge by the name of the principal river draining it—Richibucto—which in the Micmac means "river of fire."

pine (*Pinus resinosa,*) fifty-two inches ; paper birch (*Betula papyrifera*) forty-four inches ; sugar maple (*Acer saccharinum*), thirty-five inches ; swamp maple (*A. rubram*), twenty-four inches ; beech (*Fagus ferruginea*), twenty-four inches ; hacmatack (*Larix Americana*), thirty-one inches, etc. As some geological formations and soils are more favourable to tree growth than others, it follows that the rate indicated here is a local and not a general one,—on limestone areas it is doubtless, higher, on swampy coastal areas less. The hemlock, black and yellow birch and cedar have not grown again since the Miramichi fire.

Slow rate of tree growth.

From the foregoing facts, it will be seen that the general rate of tree growth in New Brunswick is by no means rapid, and that it takes even the most healthy and vigorous tree three-quarters of a century, under the most favourable conditions, to attain a size rendering it of commercial value. The slow growing trees, such as black spruce, hacmatack, maple, birch, etc., of course take longer. It has already been stated that lumbermen report being able to re-cut certain tracts of the forest every ten or twelve years and get a new crop of logs off them. This method of re-cutting the timber lands of New Brunswick periodically seems, if properly guarded, to afford a reasonable solution of the problem of forest conservation. For, if regulations prohibiting the cutting and sale of certain timber trees below a given size can be enforced, they might, in this way, become of economic value periodically, without the depletion and entire destruction of the forests as at present.

Forest conservation.

Minerals and Materials of Economic Importance.

Minerals and materials of importance.

In the superficial deposits of the region embraced in sheets No. 2, S.E., No. 4, N.W., and No. 5, S.W. of the New Brunswick maps, the following minerals and materials of economic value have been found, nearly all of which were briefly reported in the Summary Reports of 1890, 1891, 1892 and 1893. These materials may be thus enumerated : —Peat, bog-manganese, bog-iron ore, infusorial earth (tripolite), brick-clays, etc.

Peat.

Peat is developed in extensive bogs or moors on the coast of New Brunswick, bordering Northumberland Strait, and on the north-east side of Prince Edward Island. These moors have been described in detail on pages 117–122 M, and their mode of origin and economic uses in various arts and industries noted. It is evident that the value and uses of peat, and moss litter, are increasing, and that the product of the bogs is likely to come into extensive requisition as a cleansing, deodorizing and packing material.

Bog-manganese.

Bog-manganese occurs in an extensive deposit near Dawson settlement, Albert county, N.B., on a branch of Weldon Creek, covering an area of about twenty-five acres. In the centre it was found to be twenty-six feet deep, thinning out towards the margin of the bed. The mineral is a loose, amorphous mass, which can be readily shovelled without the aid of a pick, and contains more or less iron pyrites disseminated in streaks and layers, though large portions of the deposit have merely a trace. This bed of bog-manganese lies in a valley at the northern base of a hill, and its accumulation at this particular locality appears to be due to springs. These springs are still trickling down the hill-side, and doubtless the process of producing bog-manganese is still going on.

A branch of the Albert railway has been opened up to this mine, and kilns for drying the material were also erected. Operations had, however, ceased at the time of my visit (autumn of 1891) pending the completion of the analyses and tests of this product. Indications of other and similar deposits of bog-manganese further west, about the head of the branch of Weldon Creek have been reported.

Another bed of amorphous bog-manganese occurs near Harvey, in the same county, but it has not yet been opened up.

Bog-iron ore.

Bog-iron ore (limonite) in beds of considerable extent has long been known to exist at Maugerville, Sunbury county, N. B. A brief description of the deposits is given in my report on the surface geology of Western New Brunswick.*

Another deposit of this mineral, the ore being of the nature of ochre, occurs in the banks of the Northwest Miramichi River above Chaplin Island and was referred to in a previous report.† This deposit was re-examined, as it was reported that operations for the preparation of mineral paint from the material were about to be commenced. The ochre has been used for many years locally as a paint and seems to answer the purpose well. Whether it occurs in sufficient quantity to warrant the investment of capital is another question. It seems to be in process of formation still and is being deposited on the rock surfaces along the bank, through the agency of springs and of water trickling out at the contact of the superficial deposits and underlying rocks. Oozing out in this way, it collects in the crevices of the rocks in considerable quantities in certain places. Swamps and small peat bogs lie behind, and it would appear that it is the decaying organic matter from these which yields acids that aid in producing this ore.

*Report of Progress, Geol. Surv. Can., 1882-83-84, Part GG.

†Annual Report, Geol. Surv. Can., vol. III. (N.S.), 1887-88.

Bog-iron ore was also found on the south side of Buctouche harbour, in Kent County, New Brunswick, occupying an area of from five to ten acres. In several openings which were made the deposit showed a thickness of twelve or fifteen inches, and is from one to three feet below the surface of the ground.

To the south of Richibucto Head, another deposit of this material was observed. Bog-iron ore was also noticed by Mr. Wilson on the south side of Kouchibouguac River, near the mouth, and in several other places.

A noteworthy feature of these bog-iron ores is that they seem to be more abundant in the area of Carboniferous rocks than elsewhere.

Infusorial earth, or tripolite, in a thick bed, covers a portion of the bottom of Folly Lake, along the Intercolonial railway, in the Cobequid Mountains, Nova Scotia. This lake is about 600 feet above sea level, and appears to be rock-rimmed. Tripolite is also found at Fountain Lake and Sutherland's Lake further west in the Cobequids.* At the two first-mentioned lakes, efforts have been made to work the infusorial earth to some extent for use as a polishing material, and as a non-conductor of heat in covering for cylinders, etc. Infusorial earth.

Brick clay occurs in every part of the district, and usually with the fine sand necessary for the manufacture of brick in the vicinity. In the majority of cases bricks are made from marine (Leda) clay; but in a few places from boulder-clay. Brick kilns were found in operation at Lewisville, near Moncton, at Folly Point, Westmoreland county, New Brunswick, also at Amherst, Oxford, Pugwash River, near Conn's Mills, and at Wallace River, near the bridge of the Oxford and Pictou Branch railway, which crosses it. In Prince Edward Island small kilns were observed at Bloomfield station, also near Indian Point at Bedeque Bay, and a third near Cape Egmont. Brick clay.

Besides the minerals and materials mentioned as occurring in the superficial formations, all new mineral localities, wherever accessible, were examined by me, whether discovered in these or in the older rocks.

A reported coal seam near Caraquette, Gloucester county, on the south side of the mouth of the Baie des Chaleurs, was examined on two occasions with some care. It occurs in the Middle Carboniferous or Millstone grit rocks, and consisted of two thin seams with a parting of shale between them. The total thickness of the whole, including the black shale, did not exceed sixteen inches. In the hope that the seam or seams might thicken out, eastwards from the bank of the brook in which the outcrop occurs, a trench was opened, following the seam for some distance, and further east a shaft or trial-pit was sunk. The Coal seam.

*Annual Report Geol. Surv. Can., vol. I. (N.S.), 1885, pp. 70, 71 E E.

result of this exploration was not, however, satisfactory, and at present the work has been abandoned.

Silver and gold.

Argentiferous galena occurs in irregular seams, associated with pyritous minerals, on the south side of the Baie des Chaleurs at Elmtree and Nigado rivers* and at Millstream. A considerable amount of development work has been going on in these places for years, and the ore, according to several assays, yield traces of gold and some silver. Mr. Hoffmann, chemist and mineralogist to the Geological Survey, reports on a specimen from the Millstream mine submitted to him as follows :—" The specimen consisted of iron pyrites together with small " quantities of galena, and apparently trifling amounts of mispickel, " in a gangue composed of white to gray subtranslucent quartz, and a " little dark gray shale. A fair average of this specimen—which " weighed eleven pounds—was found on assay to contain :—

Gold......................0·175 of an ounce to the ton of 2,000 lbs.
Silver.....................9·450 ounces to the ton of 2,000 lbs.† "

Along the Northwest Miramichi River, between two of its affluents, the Tomogonops and Little rivers, argentiferous galena and pyrites occur, in which traces of gold are likewise reported to be found. These minerals are met with under somewhat similar conditions to the pyritous and galena ores on the south side of the Baie des Chaleurs, and appear to be of much the same character.

Magnetite.

A bed of magnetite was discovered a few years ago near the head of Millstream, Gloucester county, but a good deal of it appears to be highly charged with pyrites. Analyses by Prof. Donald, of Montreal, shown me by Mr. W. R. Payne, of Bathurst, gave upwards of 60 per cent of metallic iron with about 10 per cent of silica. Development work was undertaken here four or five years ago, but has since ceased,

The chief minerals of economic importance in the region indicated on the south side of the Baie des Chaleurs, are galena and iron pyrites, and of these there are large deposits in some places apparently in the form of irregular veins, while in others they occur more in the form of beds. The galena invariably carries a greater or less amount of silver, and traces of gold are also found, apparently in the pyritous minerals.

Supposed gold-bearing deposits at Memramcook.

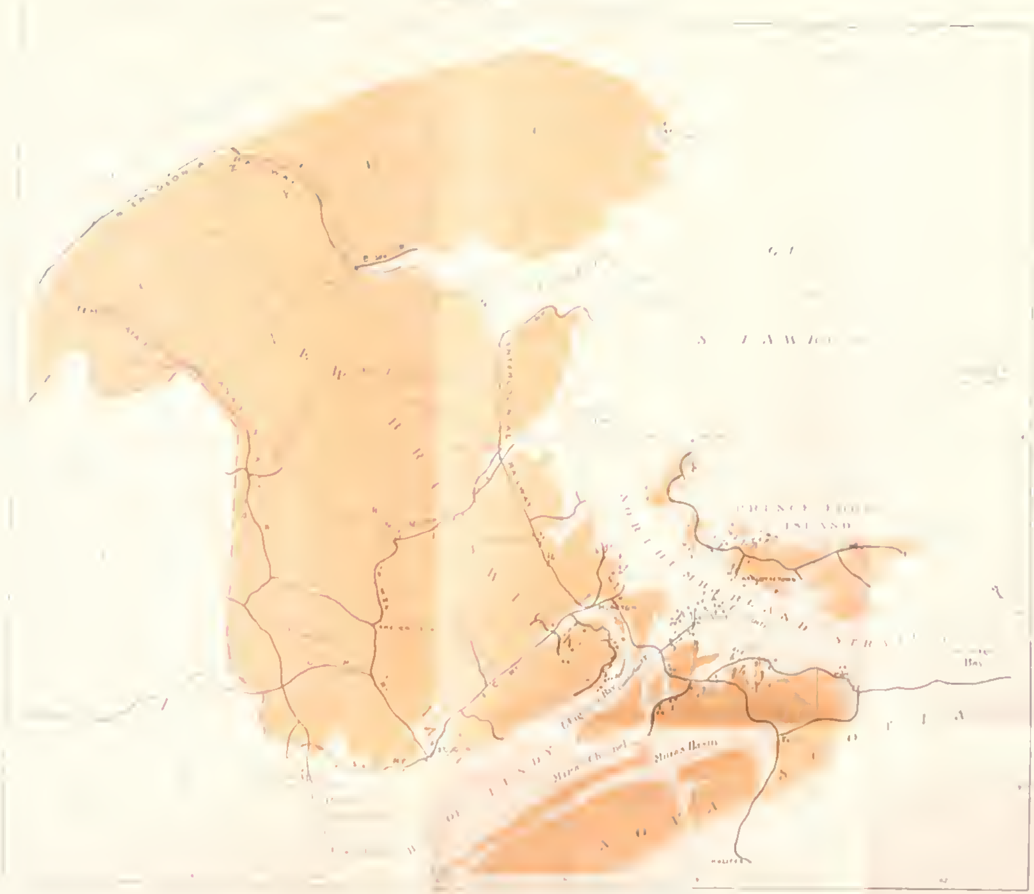
In the autumn of 1893 I made a cursory examination of the reported gold-bearing deposits at Memramcook, New Brunswick, where a 50-stamp crushing mill had been erected and where operations were in progress. The so-called gold-bearing rocks were found to be Middle Carboniferous, or Millstone grit conglomerates, which lie nearly hori-

*Report of Progress, Geol. Surv. Can., 1880-81-82, page 21 D, and page 13 H.
†Annual report Geol. Surv. of Can., vol. V. (N.S.) 1890-91, page 49 R.

zontally on the upturned edges of highly tilted Lower Carboniferous rocks. Though I did not see any of the gold, I was informed that it did actually occur in these rocks; but as the mine has since gone into liquidation, there is a disposition manifested to question the reliability of the statements made concerning it.

Geological Survey of Canada

STOCENT GLACIERS



LOCAL ... FLOATING ICE ... Pleistocene

GEOLOGICAL SURVEY OF CANADA
G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

REPORT

OF THE

SECTION OF CHEMISTRY AND MINERALOGY

BY

G. CHRISTIAN HOFFMANN, LL.D., F.I.C., F.R.S.C.,
Chemist and Mineralogist to the Survey.

Assistants

F. G. Wait, M.A., F.C.S.
R. A. A. Johnston.

OTTAWA
PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST EXCELLENT MAJESTY
1896

To

G. M. Dawson, C.M.G., LL.D., F.R.S.,

Director of the Geological Survey of Canada.

Sir,—I beg to submit, herewith, my report upon the work carried out in the Laboratory of this Survey during the year 1894. During the period in question, some six hundred and ninety-four mineral specimens were received, either for identification, for information in regard to their economic value, or for analysis or assay. The results obtained were, in a large number of instances, of no great interest save to those immediately concerned, and have, therefore, not been incorporated in the present report, which embraces only the results of such examinations, analyses and assays as were considered likely to prove of general interest.

I have the honour to be,

Sir,

Your obedient servant,

G. CHRISTIAN HOFFMANN.

Ottawa, 10th March, 1896.

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REPORT

OF THE

SECTION OF CHEMISTRY AND MINERALOGY

MISCELLANEOUS MINERALS.

1. Antimony Ochre.

This occurred as a wine-yellow, earthy incrustation, on a specimen of stibnite from the antimony mine on lot twenty-eight (fifty-six, new numbering), of the first range of the township of South Ham, Wolfe county, in the province of Quebec. Antimony ochre from South Ham, Wolfe county, Que.

Mr. R. A. A. Johnston has made an analysis of the same, and found it to have the following composition:—

Antimony tetroxide	58·86
Arsenic trioxide	7·88
Ferric oxide	2·82
Alumina	1·02
Lime	5·71
Magnesia	0·61
Water	9·46
Insoluble residue (quartz)	13·39
	99·75

2. Celestite.

This mineral has been found in considerable abundance, in a well-defined vein traversing crystalline limestone, on the second lot of the eighth concession of the township of Lansdowne, Leeds county, in the province of Ontario. Celestite from Lansdowne, Leeds county, Ont. The vein is said to have been traced for a quarter of a mile, running nearly due north-west and south-east, and to have an average width of about two feet. In some parts it consists wholly of nearly pure celestite, whilst in other parts, this mineral, associated with calcite, constitutes the gangue through which galena is irregularly distributed in crystals and small masses. A very fine specimen of the

Miscellaneous minerals, *cont.*

Celestite from Lansdowne, Leeds county, Ont., *cont.*

mineral from this vein, collected by Mr. Alex. Murray in August, 1851, and now in the mineralogical collection of the museum attached to this Survey, consists of a large tabular crystalline mass, weighing some hundred and twenty-five pounds, which, although at times colourless, for the most part has either a faint yellowish-brown tinge or is of a bluish or rarely pale reddish colour, and is semi-transparent. Mr. R. A. A. Johnston found it to have a hardness of 3·5 ; a specific gravity, at 15·5° C., of 3·958, and—agreeably with the results of his analysis (employing the ammonium chromate method for the separation of the alkaline earths)—the following composition (after drying at 100° C.—Hygroscopic water = 0·053 per cent) :—

Sulphuric acid	43·51
Strontia	56·31
Baryta	trace
Lime	0·11
	99·93

thus showing it to be almost pure strontium sulphate.

The celestite of this particular vein has inadvertently been referred to in some of the earlier reports of this Survey—namely, that for 1851-52, p. 82, and Geology of Canada, 1863, pp. 458, 688 and 771, as barite.

Celestite or native strontium sulphate, is employed for the manufacture of strontium hydrate, which is largely used in the preparation and refining of beet-root sugar, and in the extraction of crystallisable sugar from molasses ; also, for making strontium nitrate, a salt much used by pyrotechnists to produce a splendid crimson flame.

3. Galena, with Free Sulphur.

Galena, with free sulphur, from West Kootanie, B.C.

From the Ruecau claim, Kaslo-Slocan mining camp, West Kootanie district, province of British Columbia. Collected by Mr. R. G. McConnell, who informed me that it represented certain portions of the ore at this claim, which had been found to possess the somewhat unusual property of readily igniting and burning in the open air.

The specimen consists of a somewhat coarse-crystalline galena, which, from the diverse disposition of the cleavage planes of the crystalline aggregate, and consequent variation in the quantity of light reflected, presents a sparkling appearance, and is locally known as "spangle ore." It has a bright metallic lustre, and there are no visible signs of its having undergone any alteration, notwithstanding

which, as the after examination showed, this is very far from being the case. Brought into contact with the flame of a lamp, it readily takes fire, burning with a pale-blue flame and sulphurous odour. On digesting the finely powdered mineral with carbon disulphide, and allowing this to evaporate, there remains a deposit of pure sulphur, and from the residue left by this treatment, a solution of ammonium acetate removes a large amount of lead sulphate.

Miscellaneous minerals, *cont.*

Galena, with free sulphur, from West Kootanie, B.C., *cont.*

An analysis by Mr. R. A. A. Johnston gave :—

Sulphur, free	3·95
Sulphur, combined	7·48
Sulphuric acid (SO_4)	12·61
Lead	72·19
Antimony	0·85
Iron	0·29
Zinc	1·08
Silver	0·72
	99·17

These figures are the mean of two very closely concordant analyses. The deficiency most probably represents oxygen, in combination with one or other of the metals. No trace of carbonate could be detected. The sulphuric acid found would correspond to 39·81 of lead sulphate.

4. Amorphous Graphite.

An impure amorphous graphite has lately been met with, on the thirteenth lot of the eighth concession of the township of Marmora, Hastings county, in the province of Ontario, where it is said to occur in some abundance.

Amorphous graphite, from Marmora, Hastings county, Ont.

The mineral is very fine-granular, massive ; uneven in fracture ; grayish-black in colour ; dull, but assuming the lustre of graphite under the burnisher. It contains a little finely disseminated pyrite, and exposed surfaces are, in parts, more or less coated with ferric hydrate. By prolonged calcination in the open air, the graphite is burned away, leaving a brownish-yellow to reddish-brown coloured, light, cellular mass, retaining the form and dimensions of the fragment of mineral originally employed in the experiment. After drying at 100°C., whereby it lost 0·07 per cent of hygroscopic water, the mineral was found to contain :—

Graphite	72·13
Foreign mineral matter	27·86
	99·99

Miscellaneous minerals, *cont.*

The graphite, which was separated and weighed as such, had a grayish-black colour, was devoid of lustre, and apparently amorphous. The ash was found by Mr. Johnston to consist, approximately, of silica 36·0, alumina 32·8, ferric oxide 11·2, lime 2·0, and magnesia 7·6 per cent—no other constituents were sought for.

5. Plumbiferous Tetrahedrite.

Plumbiferous tetrahedrite, from West Kootanie, B.C.

From the Antelope claim, Kaslo-Slocan mining camp, West Kootanie district, province of British Columbia. Collected by Mr. R. G. McConnell.

Of the specimens examined, some consisted of the tetrahedrite in question, associated with galena and small quantities of sphalerite and pyrite: others, of the perfectly pure mineral in a gangue of white opaque quartz. The latter furnished the material employed for the analysis.

It is massive, with an indistinct fibrous structure; colour, iron-gray; streak, dark clove-brown; lustre, metallic; acquires a beautifully irised tarnish—the colours being various shades of yellow, green, blue and purple; specific gravity (after correction for a little intermixed quartz), at 15·5° C., 5·082.

An analysis by Mr. R. A. A. Johnston, upon carefully selected material, afforded the results given under I. Deducting the gangue (silica) and recalculating the remaining constituents for one hundred parts, we obtain the figures given under II.

	I.	II.
Sulphur	20·59	21·68
Antimony	26·81	28·22
Arsenic	0·22	0·23
Copper	21·03	22·14
Silver	10·64	11·20
Lead	8·91	9·38
Zinc	5·91	6·22
Iron	0·88	0·93
Gangue (quartz)	5·57	......
	100·56	100·00

A mineral of somewhat rare occurrence.

MINERALOGICAL NOTES.

Allanite.

1.—Allanite. A very noteworthy occurrence of allanite has been made known by Mr. N. J. Giroux, who recognized this mineral as entering largely into the composition of a coarse granite which

occurs in considerable masses on the east shore of Lac à Baude, Champlain county, in the province of Quebec. In this rock, the allanite, which has a deep brownish-black colour and a vitreous lustre, occurs in the form of flat tabular crystallizations which are in some instances three inches in length by three-quarters of an inch in thickness, and constitutes, according to the determinations of Mr. R. A. A. Johnston, made upon a fragment of the rock weighing very nearly seven and a half pounds, not less than close upon fifty-six per cent, by weight, of the whole. Mineralogical notes, *cont.* Allanite, *cont.*

2.—Alunogen. Specimens of this, collected by Mr. J. McEvoy during the past season, consist of thick, yellowish-white, in parts, ochre-yellow, crystalline crusts of hydrous aluminium sulphate, on a somewhat weathered pyritous quartzo-felspathic rock which occurs on Blair Creek, a branch of Bolean or Six-mile Creek, Salmon River, Grande Prairie, Yale district, province of British Columbia. Alunogen.

3.—Aragonite. Has been recognized by Mr. R. A. A. Johnston, amongst other specimens collected by Dr. G. M. Dawson, as occurring in the form of grayish-white, translucent, radiate columnar crystalline masses, filling amygdaloidal cavities in a dark greenish-gray basalt from Mussel Creek, a tributary of the Horsefly River, Cariboo district, province of British Columbia. Aragonite.

4.—Bournonite. A compact massive variety of this mineral has been met with, associated with small quantities of pyrite, in a gangue consisting of an association of bluish-gray, fine-crystalline, and grayish-white, coarse-crystalline, dolomite and white translucent quartz, on the fourteenth lot of the twelfth concession of the township of Bagot, Renfrew county, in the province of Ontario. Bournonite.

5.—Göthite. This mineral has been met with in beautiful stalactitic forms of a deep blackish-brown colour, with velvety surface and delicate radiated structure, encrusting a compact massive variety of the same mineral, at the iron mines, Bridgeville, East River, Pictou county, in the province of Nova Scotia. Göthite.

6.—Grossularite. Fine groups of yellowish-white, opaque, crystals of calcium-aluminium garnet, many of which, except at the points of attachment, were almost perfect trapezohedrons, the largest of which were some eight or nine millimetres in diameter, have been found at Lepas Bay, immediately south of Cape Knox, west coast of Graham Island, Queen Charlotte Islands, British Columbia. Grossularite.

7.—Leucite. Boulders of a dark gray leucite rock with embedded crystals of smoke-gray, sub-translucent leucite, some of which Leucite.

Mineralogical notes, *cont.*

Leucite, *cont.*

measured twenty-two and twenty-seven millimetres across, have been met with by Dr. G. M. Dawson in the auriferous gravel at the Horsefly mine, on Horsefly River, about seven miles from its entry into Quesnel Lake, Cariboo district, province of British Columbia. This mineral had not previously been met with in Canada.

Meymacite.

8.—Meymacite. A dull to bright yellow coloured ochre is found, at times in some little quantity, accompanying the scheelite found on lot one of the seventh range of the township of Marlow, Beauce county, in the province of Quebec. A specimen of this has been examined by Mr. R. A. A. Johnston, and found to contain (what may be considered as impurities, not being taken into account) 7·2 per cent of water, thus showing it to be a hydrated tungstic oxide.

Opal, common.

9.—Opal, common. A finely laminated, massive, light to dark yellow-gray, opaque (translucent in thin laminae), sub-resinous variety of opal, has been met with by Dr. G. M. Dawson, forming layers in finely bedded shales in a series of Tertiary argillites and sandstones at the Horsefly mine, on Horsefly River, about seven miles from its entry into Quesnel Lake, Cariboo district, province of British Columbia.

Pyrrhotite, crystals of.

10.—Pyrrhotite, Crystals of. In the course of examining some specimens of grossularite from the north-half of lot six of the first concession of the township of Wakefield, Ottawa county, province of Quebec, Mr. R. A. A. Johnston observed, in the gangue accompanying the garnet, some very perfect, small hexagonal tabular crystals, of from one to three millimetres in diameter, formed by the combination of the basal plane with an acute pyramid.

Scheelite.

11.—Scheelite. A light smoke gray, sub-translucent, massive mineral, with vitreous lustre, which on examination proved to be scheelite, has been found, associated with a little arsenopyrite and pyrite, in a quartz-lead intersecting the main auriferous vein, at the Ballou or old American mine, Malaga gold mining district, Queen's county, province of Nova Scotia.

Sphærosiderite.

12.—Sphærosiderite. Among other mineral specimens collected by Dr. G. M. Dawson was one which has been identified by Mr. R. A. A. Johnston as being this variety of siderite. It occurs in massive globular concretions having a marked concentric and indistinct sub-fibrous structure and a pale yellowish-gray colour, filling amygdaloidal cavities, some of which measured seventeen

and nineteen millimetres across, in a dark greenish-gray basalt, which also contained amygdules of aragonite and cavities lined with hyalite, from Mussel Creek, a tributary of the Horsefly River, Cariboo district, province of British Columbia. This mineral had not previously been recognized as occurring in Canada. Mineralogical notes, *cont.*

13.—Stilpnomelane. Has been observed, in the form of circularly-radiated plumose groupings, of a light to dark-yellow green-gray colour and vitreous to pearly lustre, as a thin coating on the fissure surfaces of a grayish-white chalcedony, from the west side of Partridge Island, Cumberland county, in the province of Nova Scotia. The mineral which was collected by Mr. C. W. Willimott in 1892 was identified by Mr. R. A. A. Johnston, but the matter was not, at the time, considered of sufficient importance to call for any special mention. Stilpnomelane.

COALS.

(Continued from p. 13 R of Annual Report of this Survey, 1892-93.)

86.—Coal. From near Coal Creek, north side of Bow River, section 22, township 27, range 5, west of the fifth initial meridian, district of Alberta, North-west Territory. Seam described as being twenty inches thick. Geological position—Lower Laramie. Coal from Coal Creek Alberta, N. W. T.

Structure, very fine lamellar; the lines of bedding are, however, not unfrequently very indistinct—compact; colour, black; lustre, resinous; hard and firm; fracture, uneven, at times somewhat conchoidal; does not soil the fingers; powder, brownish-black; it communicates a pale brownish-yellow colour to a boiling solution of caustic potash.

An analysis by fast coking gave :—

Hygroscopic water	2·79
Volatile combustible matter	36·90
Fixed carbon	53·40
Ash	6·91
	100·00
Coke, per cent	60·31
Ratio of volatile combustible matter to fixed carbon	1 : 1·45

It yields, by fast coking, a firm, compact coke. The gases evolved during coking burnt with a yellow, luminous, smoky flame. Colour of the ash, brownish-yellow—this, at a bright red heat, becomes very slightly agglutinated; at a most intense red heat it forms a more or less vitrified mass.

IRON ORES.

Magnetite from North Mountains, Annapolis Co., N. S.

1.—Magnetite. From North Mountains, Annapolis county, province of Nova Scotia. Examined for Mr. Isaiah Dodge.

A fine-granular magnetite. A partial analysis of this, by Mr. F. G. Wait, gave the following results :

Ferric oxide	49·70
Ferrous oxide	23·12
Titanic acid	none.
Insoluble matter, siliceous	17·96
Iron, as ferric oxide	34·79
Iron, as ferrous oxide	17·98
Total metallic iron	52·77

Hematite from North Mountains, Annapolis Co., N. S.

2.—Hematite. From the same locality as the preceding specimen. Examined for Mr. Isaiah Dodge.

A massive red hematite. Mr. Wait found it to contain :

Metallic iron	52·54	per cent.
Insoluble matter, siliceous	15·44	"
Titanic acid	none.	

Hematite from Cow Bay, Cape Breton Co., N.S.

3.—Hematite. From Cow Bay, Cape Breton county, province of Nova Scotia.

A massive, fine-granular hematite, in parts coated with earthy red oxide. Determinations by Mr. Wait gave :

Metallic iron	56·98	per cent.
Insoluble matter, quartz	9·45	"
Titanic acid	none.	

Limonite from Kilkenny, Montcalm Co., Que.

4.—Limonite. From lot seven of the seventh range of the township of Kilkenny, Montcalm county, province of Quebec.

A dark brown, massive limonite. Mr. Wait found it to contain :

Metallic iron	25·75	per cent.
Titanic acid	none.	

Magnetite from Rawdon, Montcalm Co., Que.

5.—Magnetite. From the second lot of the second range of the township of Rawdon, Montcalm county, province of Quebec.

A massive, somewhat coarsely-crystalline, magnetite. Determinations conducted by Mr. Wait gave :

Metallic iron	42·29	per cent.
Titanic acid	none.	

Magnetite from Wexford, Terrebonne Co., Que.

6.—Magnetite. From lot seven of the first range of the township of Wexford, Terrebonne county, province of Quebec.

A somewhat fine-granular magnetite in a gangue composed of quartz with some felspar and a little hornblende. Mr. Wait found it to contain : Iron ores, *cont.*

Metallic iron	20·27 per cent.
Insoluble matter	58·58 "
Titanic acid	distinct traces.

7.—Hematite with magnetite. From the west bank of Koksoak River, three miles and a-half above the mouth of Swampy-bay River, Ungava district, Labrador Peninsula. Collected by Mr. A. P. Low. Hematite with magnetite, from Koksoak River, Labrador Peninsula.

The deposit is said by Mr. Low to consist of four hundred feet of jaspery magnetite and hematite, overlain by fifty feet of cherty carbonates. The material examined, consisted of an association of hematite with a little magnetite and small quantitics of red jasper. Agreeably with determinations conducted by Mr. Wait, it contained :

Ferric oxide	80·17
Ferrous oxide	0·35
Manganous oxide	3·09
Titanic acid	none.
Insoluble matter, siliceous	13·78
Metallic iron, total amount of	56·39

8.—Magnetite with hematite. From the west bank of Koksoak River, four miles above the mouth of Swampy-bay River, Ungava district, Labrador Peninsula. Collected by Mr. A. P. Low. Magnetite with hematite, from Koksoak River, Labrador Peninsula.

The deposit, according to Mr. Low, consists of two hundred feet of jaspery magnetite and hematite, underlain by fifty feet of garnetiferous siliceous shale and banded jasper, all highly ferruginous.

Specimen of material from the upper part of the deposit. It consisted of an association of magnetite with some hematite and quartz. Mr. Wait found it to contain :

Metallic iron	48·29 per cent.
Insoluble matter	30·62 "
Titanic acid	none.

9.—Magnetite. From the same locality as the preceding specimen. Magnetite, from Koksoak River, Labrador Peninsula.

Specimen of material from the lower part of the deposit. It consisted of magnetite disseminated through a garnetiferous rock. Determinations by Mr. Wait gave :

Metallic iron	19·14 per cent.
Insoluble matter	72·86 "
Titanic acid	none.

Iron ores, *cont.*

Ankerite with magnetite, from Koksoak River, Labrador Peninsula.

10.—Ankerite with magnetite. From the left bank of Koksoak River, immediately below the Shale Chute or a few miles below Cambrian Lake, Ungava district, Labrador Peninsula. Collected by Mr. A. P. Low, who informs me that the deposit consists of twenty feet of cherty limestone holding masses of ankerite, with thin beds of jaspery magnetite below.

Specimen of material from the upper part of the deposit. It consisted of an association of ankerite and magnetite through which was disseminated a small amount of rock matter. A partial analysis, by Mr. Wait, gave:

Ferric oxide	23·43
Ferrous oxide	21·32
Manganous oxide	1·34
Titanic acid	none.
Insoluble matter	6·72
Iron, as ferric oxide	16·40
Iron, as ferrous oxide	16·58
Total metallic iron	32·98

Magnetite, from Koksoak River, Labrador Peninsula.

11.—Magnetite. From the same locality as the preceding specimen.

Specimen of material from the lower part of the deposit. It consisted of a fine-granular magnetite in a quartzose gangue. Mr. Wait found it to contain:

Metallic iron	31·28 per cent.
Insoluble matter	55·71 "
Titanic acid	none.

Magnetite from between Petitsikapou and Dyke Lakes, Labrador Peninsula.

12.—Magnetite. From narrows between Petitsikapou and Dyke Lakes, Ashuanipi branch of Hamilton River, Ungava district, Labrador Peninsula. Collected by Mr. A. P. Low.

The deposit consists, according to Mr. Low, of twenty feet of jaspery magnetite, associated with thick beds of cherty carbonates of iron and lime.

A fine-granular magnetite in a gangue of quartz. Determinations by Mr. Wait gave:

Metallic iron	30·43 per cent.
Insoluble matter	51·22 "
Titanic acid	none.

Magnetite with hematite, Menihek Lake, Labrador Peninsula.

13.—Magnetite with hematite. From outlet of Menihek Lake, Ashuanipi branch of Hamilton River, Ungava district, Labrador Peninsula. From large angular blocks of flat-bedded jaspery ore, apparently resting upon fine-grained, dark green, bedded trap. Collected by Mr. A. P. Low.

An association of hematite, magnetite and red jasper. It was found by Mr. Wait to contain: Iron ores, *cont.*

Metallic iron	40·72 per cent.
Insoluble matter	29·90 "
Titanic acid	none.

14.—Magnetite. From the eleventh lot of the first concession of the township of Minden, Haliburton county, province of Ontario. This, and the four following specimens were collected by Dr. F. D. Adams. Magnetite from Minden, Haliburton Co., Ont.

A somewhat fine-granular magnetite, through which was disseminated a large amount of rock matter. A determination by Mr. Wait gave:

Metallic iron	30·29 per cent.
Titanic acid	distinct traces.

15.—Magnetite. From the fifteenth lot of the eighth concession of the township of Digby, Victoria county, province of Ontario. Magnetite from Digby, Victoria Co., Ont.

A compact, massive magnetite, with which was associated a somewhat large amount of rock matter. It was tested for, and found to contain distinct traces of titanic acid.

16.—Magnetite. From lot five of the fifth and sixth concessions of the township of Lutterworth, Haliburton county, province of Ontario. Magnetite from Lutterworth, Haliburton Co., Ont.

A somewhat fine-crystalline, massive magnetite, through which was disseminated a comparatively large amount of gangue, composed, for the most part, of hornblende, quartz, garnet and calcite. It was examined for, and found to be quite free from titanic acid.

17.—Magnetite. From the twenty-third lot of the twelfth concession of the township of Galway, Peterborough county, province of Ontario. Magnetite from Galway Peterborough Co., Ont.

A somewhat fine-crystalline granular, massive magnetite, through which was disseminated a rather large amount of gangue. It was examined for titanic acid, and with negative results.

18.—Magnetite. From lot twenty of the first concession of the township of Snowdon, Peterborough county, province of Ontario. Magnetite from Snowdon, Peterborough Co., Ont.

A fine-crystalline granular, massive magnetite, through which was disseminated small quantities of pyrrhotite. No evidence was obtained of the presence of titanic acid in this particular speci-

Iron ores, *cont.*

men. It should, however, be mentioned, that a specimen from precisely the same locality, was examined by Professor E. J. Chapman, some years back, and found to contain 0·73 per cent titanium dioxide.

NICKEL AND COBALT.

Estimation of, in pyrrhotite from some localities in the provinces of Ontario and British Columbia.—Continued from page 43R of last Annual Report of this Survey, vol. vi., 1892-93.

Pyrrhotite from Minden, Haliburton Co., Ont.

1.—From Twelve-mile Lake, township of Minden, Haliburton county, province of Ontario.

An association of a compact, massive, pyrrhotite with a little pyrite, through which was disseminated small quantities of a quartzose gangue. An analysis by Mr. Wait showed it to contain:

Nickel	0·13 per cent.
Cobalt	trace.

The gangue constituted 6·92 per cent, by weight, of the whole. The metalliferous portion of the ore contained, therefore, 0·14 per cent nickel.

Pyrrhotite from Sebastopol, Renfrew Co., Ont.

2.—From lots thirty-two and thirty-three of the eleventh concession of the township of Sebastopol, Renfrew county, province of Ontario. Examined for Mr. L. Meany.

The material consisted of an association of a compact, massive, pyrrhotite with small quantities of chalcopyrite and pyrite, in a gangue composed of calcite and pyroxene, some hornblende, felspar and a little garnet. The pyrrhotite, free from all gangue, was found by Mr. Wait to contain:

Nickel	0·10 per cent.
Cobalt	none.

Pyrrhotite from West Kootanie, B.C.

3.—From the King Solomon mine, Kaslo-Slocan mining camp, West Kootanie district, province of British Columbia. Examined for Mr. H. E. Porter.

A compact, massive, pyrrhotite, through which was disseminated very small quantities of a white sub-translucent quartz—amounting to 0·36 per cent. Determinations by Mr. Wait gave:

Nickel	0·15 per cent.
Cobalt	trace.

4.—From the east side of Upper Arrow Lake, about twelve miles from its head, West Kootanie district, province of British Columbia. Examined for Mr R. Sanderson.

Nickel and cobalt, *cont.*

Pyrrhotite from Upper Arrow Lake, B.C.

The material consisted of an association of white sub-translucent quartz with a little chlorite and, here and there, a few scales of mica—carrying small quantities of a compact, massive, pyrrhotite, a little pyrite and a few specks of chalcopyrite. The pyrrhotite, free from all gangue, was found by Mr. Wait to contain:

Nickel	0·12 per cent.
Cobalt	none.

CALCAREOUS MARLS.

Calcareous marl is found in nearly all parts of Canada, but is more especially abundant in the provinces of Quebec and Ontario, where large, and often very extensive, deposits are frequently met with. Marl, either alone or composted, constitutes an excellent fertilizer, and may be advantageously employed in certain forms and quantities, and under proper circumstances, to all soils—clayey, sandy, loamy or peaty. Its action is both mechanical and chemical—mechanical, by rendering the soil more pulverulent and open, a matter of great importance, and—chemical, by supplying certain inorganic elements of plant food, namely, lime, small quantities of phosphoric acid, potash, etc. It is also used in the manufacture of an artificial Portland cement—the marl being mixed, wet, with a certain proportion of clay, the resulting mass dried and calcined, and then ground to the proper fineness. When calcined, many marls yield a nearly pure and very white lime, well adapted for mortar and other uses. For this purpose, the marl is moulded into shapes like bricks, which are dried and then burned in a kiln. The purer varieties may be used as a substitute for prepared chalk or whiting, in cleaning metals, and for similar purposes. In many parts of the country, it is commonly employed by the people for white-washing their buildings.

The following are analyses of this material from a few of some of the better known deposits.

1.—From Marl Lake, at the west end of the island of Anticosti, province of Quebec. The lake has an area of about ninety acres, and is covered at the bottom with marl, apparently of considerable thickness.

Marl from the island of Anticosti, Que.

The air-dried material is earthy, somewhat coherent; colour, grayish-white. It contains numerous shells and some root-fibres.

Calcareous marls, *cont.*

Marl from the island of Anticosti, Que., *cont.*

An analysis, by Mr. F. G. Wait, showed it to have the following composition :

(After drying at 100° C.—Hygroscopic water = 0·70 per cent.)

Lime	50·83
Magnesia	0·02
Alumina	0·02
Ferric oxide	0·08
Potassa	0·02
Soda	0·17
Carbonic acid	40·06
Sulphuric acid	0·15
Phosphoric acid	0·02
Silica, soluble	0·07
Insoluble mineral matter	2·88
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.—and possibly a little combined water	5·44
	99·76

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 90·77 per cent carbonate of lime.

The insoluble mineral matter was found to consist of:

Silica	1·99
Alumina	0·47
Ferric oxide	0·14
Manganous oxide	0·01
Lime	0·16
Magnesia	0·03
Alkalies?	0·07
	2·88

Marl from Stanstead, Stanstead Co., Que.

2.—From a deposit occurring on lots four and five of ranges ten and eleven of the township of Stanstead, Stanstead county, province of Quebec. The deposit is reported to extend over an area of some twenty acres, and to be from thirty to forty feet thick. The material examined was taken from the fourth lot of the eleventh range of the township in question.

The air-dried material is earthy, somewhat coherent ; colour, yellowish-white. It contains a few shells, and some root-fibres.

It was found, by Mr. F. G. Wait, to have the following composition :

(After drying at 100° C.—Hygroscopic water = 0·72 per cent.) Calcareous marls, *cont.*

Marl from Stanstead, Stanstead Co., Que., *cont.*

Lime	50·65
Magnesia	0·10
Alumina	0·24
Ferric oxide	0·11
Manganous oxide	traces.
Potassa	traces.
Soda	traces.
Carbonic acid	39·73
Sulphuric acid	0·15
Phosphoric acid	0·01
Silica, soluble	0·03
Insoluble mineral matter	1·76
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	7·17
	99·95

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 90·44 per cent carbonate of lime.

The insoluble mineral matter was found to consist of:

Silica	1·07
Alumina and ferric oxide	0·57
Lime	0·05
Magnesia	traces.
Alkalies?	0·07
	1·76

3.—From a deposit on the east side of MacKay's or Hemlock Lake, lots one and two of the junction Gore of the township of Gloucester, Carleton county, province of Ontario. The deposit has a thickness of about five feet, but its extent is not known. Marl from Gloucester, Carleton Co., Ont.

The air-dried material is earthy, slightly coherent: colour, yellowish-white. It contains numerous shells, also root-fibres.

Agreeably with the results of an analysis, conducted by Mr. F. G. Wait, it has the following composition:

(After drying at 100° C.—Hygroscopic water = 0·46 per cent.)

Lime	52·24
Magnesia	0·13
Alumina	0·13
Ferric oxide	0·09
Potassa	traces.

Calcareous marls, *cont.*

Marl from Gloucester, Carleton Co., Ont., *cont.*

Soda	traces.
Carbonic acid	41·16
Sulphuric acid	traces.
Phosphoric acid	0·02
Silica, soluble	0·11
Insoluble mineral matter	1·08
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	4·90
	99·86

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93·29 per cent carbonate of lime.

The insoluble mineral matter was found to consist of:

Silica	0·72
Alumina and ferric oxide	0 24
Lime	0·04
Magnesia	0·02
Alkalies?	0·06
	1·08

Marl from Lavant, Lanark Co., Ont.

4.—From a deposit on the thirteenth lot of the fourth concession of the township of Lavant, Lanark county, province of Ontario. The deposit covers an area of rather more than six acres, and is over seven feet deep.

The air-dried material is earthy, slightly coherent; colour, yellowish-white. It contains but few shells or root-fibres.

Its composition was found, by Mr. F. G. Wait, to be as follows:

(After drying at 100° C.—Hygroscopic water = 0·52 per cent.)

Lime	53·17
Magnesia	0·06
Alumina	0·10
Ferric oxide	0·08
Manganous oxide	0·02
Soda	0·10
Carbonic acid	42·02
Sulphuric acid	traces.
Phosphoric acid	0·01
Silica, soluble	0·02
Insoluble mineral matter	0·24
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	3·66
	99·48

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 94·95 per cent carbonate of lime. *Calcareous marls, cont.*

The insoluble mineral matter was found to consist of :

Silica	0·15
Alumina and ferric oxide	0·07
Lime	0·01
Magnesia	traces.
Alkalies?	0·01
	0·24

5.—From a deposit occurring on lots fifteen and sixteen of the second concession of the township of Sheffield, Addington county, province of Ontario. The deposit extends over an area of two hundred acres, and perhaps more, with a thickness, over the greater portion, of at least ten feet. Marl from Sheffield, Addington Co., Ont.

The air-dried material is earthy, friable ; colour, light gray. It contains numerous shells ; also some wood-fibres.

Its analysis afforded Mr. F. G. Wait the following results :

(After drying as 100° C.—Hygroscopic water = 0·82 per cent.)

Lime	51·97
Magnesia	0·36
Alumina	0·03
Ferric oxide	0·09
Potassa	traces.
Soda	0·08
Carbonic acid	41·34
Sulphuric acid	0·03
Phosphoric acid	0·02
Silica, soluble	0·03
Insoluble mineral matter	0·71
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, &c.,—and possibly a little combined water	5·96
	100·62

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92·80 per cent carbonate of lime.

Calcareous marls, *cont.*

The insoluble mineral matter was found to consist of:

Silica	0·48
Alumina and ferric oxide	0.13
Lime	0·03
Magnesia	0·02
Alkalies?	0·05
	0·71

Marl from Reach, Ontario Co., Ont.

6.—From Chalk Lake, lots one and two of the first, and lot one of the second, concession of the township of Reach, Ontario county, province of Ontario. The lake has an area of about seventy-five acres. The marl, which forms the bottom of the lake, is, apparently, of considerable thickness, but its exact measure has not been ascertained.

The air-dried material is earthy, somewhat coherent; colour, yellowish-white. It contains root-fibres and some shells.

An analysis, by Mr. F. G. Wait, showed it to have the following composition:

(After drying at 100° C.—Hygroscopic water = 0·01 per cent.)

Lime	51·88
Magnesia	0·07
Alumina	0·09
Ferric oxide	0·08
Potassa	traces.
Soda	traces.
Carbonic acid	40·86
Sulphuric acid	0·06
Phosphoric acid	0·01
Silica, soluble	0·05
Insoluble mineral matter	2·11
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	4·77
	99·98

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92·64 per cent carbonate of lime.

The insoluble mineral matter was found to consist of:

Silica	1·57
Alumina and ferric oxide	0·38
Lime	0·06
Magnesia	0·02
Alkalies?	0·08
	2·11

7.—From a deposit at White Lake, lots eighteen and nineteen of the ninth concession of the township of Huntingdon, Hastings county, province of Ontario. The marl extends out from the shore beneath the waters of the lake for variable distances—at some points, for one hundred feet or less; at others, for over two hundred feet or more. Little is known in regard to the thickness of the deposit, but this, in some places at least, has been found to exceed thirty feet.

Calcareous marls, *cont.*

Marl from Huntingdon, Hastings Co., Ont.

The air-dried material is earthy, slightly coherent; colour, yellowish-white. It contains but few shells, and no visible root-fibres.

It was found, by Mr. F. G. Wait, to have the following composition:

(After drying at 100° C.—Hygroscopic water = 0·75 per cent.)

Lime	54·47
Magnesia	0·11
Alumina	0·06
Ferric oxide	0·08
Manganous oxide	traces.
Potassa	traces.
Soda	traces.
Carbonic acid	42·87
Sulphuric acid	0·03
Phosphoric acid	0·01
Silica, soluble	0·08
Insoluble mineral matter	1·08
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	1·84
	100·63

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 97·27 per cent carbonate of lime.

The insoluble mineral matter was found to consist of:

Silica	0·82
Alumina and ferric oxide	0·21
Lime	0·03
Magnesia	traces.
Alkalies ?	0·02
	1·08

8.—From a deposit on the twelfth lot of concession A, Coulonge Lake Front, township of Westmeath, Renfrew county, province of Ontario. The deposit is about one hundred and thirty-five yards

Marl from Westmeath, Renfrew Co. Ont.

Calcareous marls, *cont.*

Marl from Westmeath, Renfrew Co., Ont., *cont.*

in length and and some seventy-four yards in width. It consists of two distinct, continuous layers—an upper dark coloured layer, twenty-two inches thick ; and a lower light coloured layer, fourteen inches thick.

(*a*) The material of the upper layer, in the air-dried condition, is earthy, slightly coherent ; colour, light gray. It contains some shells, and also some root-fibres. A partial analysis of this, by Mr. F. G. Wait, showed it to contain (after drying at 100° C.—Hygroscopic water = 0·99 per cent) ; lime 52·31, which would correspond to 93·41 per cent carbonate of lime, insoluble mineral matter 0·88, organic matter—consisting of vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc., and possibly a little combined water—5·27, phosphoric acid 0·04.

(*b*.) The material of the lower layer, in the air-dried condition, is earthy, loosely coherent ; colour, yellowish-white. It contains some shells, but no visible root-fibres.

An analysis, by Mr. F. G. Wait, showed it to contain :

(After drying at 100° C.—Hygroscopic water = 0·29 per cent.)

Lime	51·68
Magnesia	0·51
Alumina	0·12
Ferric oxide	0·09
Carbonic acid	41·18
Sulphuric acid	0·03
Phosphoric acid	0·02
Silica, soluble	0·09
Insoluble mineral matter	4·06
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	2·71
	100·49

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 92·28 per cent carbonate of lime.

The insoluble mineral matter was found to consist of :

Silica	2·85
Alumina and ferric oxide	0·82
Lime	0·14
Magnesia	traces.
Alkalies ?	0·25
	4·06

9.—From a deposit three feet thick, underlying three feet of peat, in the neighbourhood of the Eramosa branch of the Green River, township of Eramosa, Wellington county, province of Ontario.

Calcareous marls, *cont.*

Marl from Eramosa, Wellington Co., Ont.

The air-dried material is earthy, friable ; colour, light gray. It contains but few shells or root-fibres.

Its composition was found by Mr. F. G. Wait to be as follows :

(After drying at 100° C.—Hygroscopic water = 0·76 per cent.)

Lime	43·71
Magnesia	0·76
Alumina	0·16
Ferric oxide	0·29
Potassa	traces.
Soda	traces.
Carbonic acid	34·87
Sulphuric acid	0·34
Phosphoric acid	0·03
Silica, soluble	0·33
Insoluble mineral matter	10·36
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	9·79
	100·64

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 78·05 per cent carbonate of lime.

The insoluble mineral matter was found to consist of :—

Silica	7·74
Alumina	1·52
Ferric oxide	0·37
Lime	0·24
Magnesia	0·08
Alkalies ?	0·41
	10·36

10.—From a deposit occurring on lot twenty-four of the ninth concession of the township of Artemesia, Grey county, province of Ontario. The deposit covers about twelve acres, and has a depth of at least seven feet.

Marl from Artemesia, Grey Co., Ont.

The air-dried material is earthy, slightly coherent ; colour, yellowish-white. It contains a few shells and some root fibres.

It was found, by Mr. F. G. Wait, to have the following composition :

Calcareous marls, *cont.*

Marl from Artemesia, Grey Co., Ont., *cont.*

(After drying at 100° C.—Hygroscopic water = 0·34 per cent.)

Lime	48·73
Magnesia	0·73
Alumina	0·28
Ferric oxide	0·25
Manganous oxide	traces.
Potassa	traces.
Soda	traces.
Carbonic acid	38·99
Sulphuric acid	0·06
Phosphoric acid	0·02
Silica, soluble	0·21
Insoluble mineral matter	8·30
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	3·30
	100·87

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 87·02 per cent carbonate of lime.

The insoluble mineral matter was found to consist of:

Silica	5·56
Alumina and ferric oxide	2·17
Lime	0·06
Magnesia	0·04
Alkalies	0·47
	8·30

Marl from Keppel, Grey Co., Ont

11.—From a deposit at Shallow Lake, township of Keppel, Grey county, province of Ontario. The deposit extends over an area of upwards of five hundred acres, and has an average depth of about six or seven feet.

The air-dried material is earthy, somewhat coherent; colour, almost white. It contains no visible shell remains or root-fibres.

An analysis, by Mr. F. G. Wait, showed it to contain:

(After drying at 100° C.—Hygroscopic water = 0·30 per cent.)

Lime	52·52
Magnesia	1·04
Alumina	0·08
Ferric oxide	0·16
Manganous oxide	traces.
Carbonic acid	42·47
Sulphuric acid	0·02
Phosphoric acid	0·01

Calcareous marls, *cont.*

Marl from Keppel, Grey Co., Ont., *cont.*

Silica, soluble	0·08
Insoluble mineral matter	1·74
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water	2·70
	100·82

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in other forms of combination, the amount found would correspond to 93·79 per cent carbonate of lime.

The insoluble mineral matter was found to consist of :

Silica	1·22
Alumina and ferric oxide	0·32
Lime	0·03
Magnesia	traces.
Alkalies?	0·17
	1·74

Marl from Emerald Lake, district of Nipissing, Ont.

12.—From a deposit in Emerald Lake, five miles west of Opemicon Narrows, between Mattawa and Lake Temiscamingue, Ottawa River, district of Nipissing, province of Ontario. Collected by Mr. A. E. Barlow.

The air-dried material is earthy, somewhat coherent; colour, light gray. It contains a few shells, also some root-fibres.

Mr. F. G. Wait found it to contain :

(After drying at 100° C.—Hygroscopic water = 1·06 per cent.)

Lime	48·32
Magnesia	0·04
Alumina	0·07
Ferric oxide	0·08
Manganous oxide	traces.
Potassa	traces.
Soda	traces.
Carbonic acid	38·01
Sulphuric acid	0·07
Phosphoric acid	0·02
Silica, soluble	0·10
Insoluble mineral matter	8·62
Organic matter, viz., vegetable fibre in a state of decay, and products of its decay, such as humus, humic acid, etc.,—and possibly a little combined water.	4·79
	100·12

Assuming the whole of the lime to be present in the form of carbonate, trifling quantities of which are, however, present in

Calcareous marls, *cont.*

other forms of combination, the amount found would correspond to 86·28 per cent carbonate of lime.

The insoluble mineral matter was found to consist of :

Silica	6·24
Alumina and ferric oxide	1·51
Lime	0·29
Magnesia	0·08
Alkalies ?	0·50
	8·62

Gold and silver assays.

GOLD AND SILVER ASSAYS.

These were all conducted by Mr. R. A. A. Johnston.

Province of Nova Scotia.

Province of Nova Scotia.

1.—From West River, Pictou county.

An intimate association of iron-pyrites, galena, zinc-blende and calcite. Weight of specimen, fourteen ounces.

It contained neither gold nor silver.

2.—From the Columbia Milling Company's mine, Oldham, Halifax county.

Tailings, consisting for the most part of quartz, with a few scales of mica. Weight of sample, seven pounds twelve ounces. Assays gave :

Gold	trace.
Silver	none.

Province of New Brunswick.

Province of New Brunswick.

3.—From Kelley's Brook, Queen's county. Collected by Mr. J. Wilson. A white opaque, in parts, rust stained quartz, through which were disseminated small quantities of iron-pyrites.

It contained neither gold nor silver.

4.—From a few miles north of Bathurst, Gloucester county. Examined for Mr. Edward Jack.

A more or less intimate mixture of zinc-blende, galena and iron-pyrites together with small quantities of pyrrhotite, mispickel and copper-pyrites in a gangue of quartz with a little crystalline limestone. Weight of sample, eighteen pounds. It contained :

Gold	trace.
Silver	8·167 ounces to the ton of 2,000 lbs.

PROVINCE OF QUEBEC.

Gold and silver assays, *cont.*

Province of Quebec.

5.—From lot 632 of St. George, Beauce county. Examined for Mr. L. Gendreau.

A somewhat weathered, gray gneissoid rock. Weight of sample, two pounds thirteen ounces.

It contained neither gold nor silver.

6.—From the eighteenth lot of the fourth range of the township of Inverness, Megantic county.

A gray crypto-crystalline quartz, carrying small quantities of iron-pyrites. Weight of sample, six ounces.

It contained neither gold nor silver.

7.—From the eighteenth lot of the third range of the township of Inverness, Megantic county.

An association of white opaque quartz with some dark green diorite and a little gray chloritic schist, in parts stained and coated with green carbonate of copper, carrying small quantities of copper-pyrites. Weight of sample, nine ounces.

It contained neither gold nor silver.

8.—From lot forty-one of the ninth range of the township of Ditton, Compton county. Examined for Mr. H. H. Bailey.

a. Sample taken from the surface. An association of white sub-translucent, in parts, rust-stained quartz with some dark-green to gray chloritic schist, carrying small quantities of iron-pyrites. Weight of sample, fourteen pounds.

It contained neither gold nor silver.

b. Samples taken from some little depth below the surface. The material very closely resembled that from the surface—just referred to. Weight of sample, three pounds eleven ounces.

It contained neither gold nor silver.

9.—From the so-called gold mine, St. Alphonse, Joliette county. This and the following eight specimens, were collected by Dr. F. D. Adams.

A gray granite, with here and there a few specks of iron-pyrites. Weight of sample, four pounds three ounces.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of Quebec, *cont.*

10.—From the same locality as the preceding specimen.

A gray granite, through which were disseminated small quantities of iron-pyrites. Weight of sample, three pounds thirteen ounces.

It contained neither gold nor silver.

11.—From the same locality as the two preceding specimens.

A white and bluish-white sub-translucent quartz, associated with small quantities of felspar and mica. Weight of sample, eight ounces.

It contained neither gold nor silver.

12.—From the eighth lot of the fifth range of Cathcart, Joliette county.

A rust-stained gneiss, through which were disseminated small quantitics of graphite. Weight of sample, three pounds.

It contained neither gold nor silver.

13.—From lot twenty-four of the sixth range of Rawdon, Montcalm county.

A rust-stained gneiss, through which were disseminated small quantities of iron-pyrites. Weight of sample, five pounds seven ounces.

It contained neither gold nor silver.

14.—From lot twenty-seven of the seventh range of Rawdon, Montcalm county.

A gray granitic gneiss. Weight of sample, three pounds seven ounces.

It contained neither gold nor silver.

15.—From the eleventh lot of the fourth range of Chertsey, Montcalm county.

The sample was made up of two fragments, the one a grayish-black hornblendic granite, the other a rust-stained, bluish-white quartz, carrying some iron-pyrites. Weight of sample, one pound twelve ounces.

It contained neither gold nor silver.

16.—From the same locality as the preceding specimen.

A weathered felspathic rock, carrying small quantities of iron-pyrites. Weight of sample, one pound six ounces.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of Quebec, *cont.*

17.—From the fifteenth lot of the fifth range of Chertsey, Montcalm county.

A rust-stained gray granite, carrying small quantities of iron-pyrites. Weight of sample, two pounds four ounces.

It contained neither gold nor silver.

18.—From a vein occurring on the fourth and fifth lots of the ninth range of Calumet, Pontiac county.

The crushed material, said to represent a fair average of twenty tons of the ore, consisted of a white sub-translucent to translucent quartz, with small quantities of iron-pyrites. Weight of sample, one pound.

It contained neither gold nor silver.

19.—From the East Main River. This, and the two following specimens were collected by Mr. A. P. Low.

A quartzo-felspathic rock, carrying small quantities of iron-pyrites and mispickel. Weight of sample, eleven ounces. Assays gave:

Gold.............	none.
Silver............	0·292 of an ounce to the ton of 2,000 lbs.

20.—Also from the East Main River.

A fine-granular iron-pyrites. Weight of sample, four ounces. It was found to contain:

Gold.............	trace.
Silver...........	0·175 of an ounce to the ton of 2,000 lbs.

21.—From Lake Chibougamoo.

A fine grained grayish-green diorite, more or less stained with hydrated peroxide of iron, carrying somewhat large quantities of iron-pyrites. Weight of sample, one pound eight ounces. It contained:

Gold............	none.
Silver..........	0·293 of an ounce to the ton of 2,000 lbs.

Province of Ontario.

Province of Ontario.

22.—From the west-half of the tenth lot of the sixth concession of the township of Lavant, Lanark county. Examined for Mr. James Bell.

Gold and silver assays, *cont.*

Province of Ontario, *cont.*

A rust-stained gneiss, through which were disseminated small quantities of iron-pyrites. Weight of sample, two and a half ounces. Assays gave :

Gold............ 0·175 of an ounce to the ton of 2,000 lbs.
Silver...... ..... none.

23.—From the twentieth lot of the third concession of the township of Dungannon, Hastings county. This, and the following specimen, were examined for Mr. G. L. Woodworth.

A crushed quartz-rock. Weight of sample, eight ounces.

It contained neither gold nor silver.

24.—From the same locality as the preceding specimen.

A further sample of crushed quartz-rock. Weight of sample, four ounces.

It contained neither gold nor silver.

25.—From the Ledyard gold mine, east-half of lot nineteen, concession one, of the township of Belmont, Peterborough county.

A white sub-translucent quartz, stained and coated with hydrated peroxide of iron, carrying somewhat large quantities of iron-pyrites. Weight of sample, twenty-five pounds. It was found to contain :

Gold .... 4·608 ounces to the ton of 2,000 lbs.
Silver............ ...none.

26.—From lot twenty, concession A, of the township of Galway, Peterborough county. This, and the following six specimens were collected by Dr. F. D. Adams.

A coarsely crystalline galena in a gangue of white crystalline limestone. The latter constituted but a small proportion, by weight, of the whole. Weight of sample, eleven ounces.

It contained neither gold nor silver.

27.—From lot one, of the tenth concession, of the township of Galway, Peterborough county.

A white sub-translucent quartz, stained and coated with hydrated peroxide of iron, through which were disseminated small quantities of iron-pyrites and pyrrhotite. Weight of sample, two pounds one ounce.

It contained neither gold nor silver.

28.—From the sixteenth lot of the fifteenth concession of the township of Galway, Peterborough county. Gold and silver assays, *cont.*

Province of Ontario, *cont.*

A white sub-translucent quartz, more or less stained with hydrated peroxide of iron, carrying some pyrrhotite and a small quantity of iron-pyrites. Weight of sample, one pound three ounces.

It contained neither gold nor silver.

29.—From the south-half of lot sixteen, concession fourteen, of the township of Galway, Peterborough county.

An association of a massive pyrrhotite with small quantities of copper-pyrites, quartz and felspar. Weight of sample, one pound two ounces.

It contained neither gold nor silver.

30.—From the Reynolds mine, on the eighteenth lot of the fourth concession of the township of Galway, Peterborough county.

Consisted of a massive pyrrhotite together with small quantities of iron-pyrites, in a gangue of white sub-translucent quartz. The specimen was thickly coated with hydrated peroxide of iron. Weight of sample, one pound nine ounces.

It contained neither gold nor silver.

31.—From Keloe's gold mine, lot twenty-five of the twelfth concession of the township of Dalton, Victoria county.

A very coarse granite, composed of white sub-translucent quartz, white to light salmon coloured felspar and a little black mica. Weight of sample, one pound nine ounces.

It contained neither gold nor silver.

32.—From Henderson's mine, lot one, concession eleven, of the township of Somerville, Victoria county.

An association of a white sub-translucent quartz with a little felspar, and here and there a little garnet, in parts coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites and pyrrhotite. Weight of sample, fifteen ounces.

It contained neither gold nor silver.

33.—From the twenty-eighth lot of the eighth concession of the township of Clarendon, Frontenac county. Examined for Mr. Jonathan Muldoon.

Gold and silver assays, *cont.*

Province of Ontario, *cont.*

A white sub-translucent quartz, more or less stained and coated with hydrated peroxide of iron, carrying small quantities of mispickel. Weight of sample, one pound nine ounces. Assays showed it to contain :

Gold.................. 2·098 ounces to the ton of 2,000 lbs.
Silver........... ..... none.

34.—From the north-half of lot six, concession three, of the township of Graham, district of Algoma. Examined for Mr. D. L. McLean.

An association of grayish-white sub-translucent quartz with a little gray chloritic schist, carrying small quantities of iron-pyrites, and pyrrhotite, and a very little finely crystalline galena. Weight of sample, one pound five ounces.

It contained neither gold nor silver.

35.—From the third lot of the fourth concession of the township of Shakespeare, district of Algoma. This, and the following specimen, were examined for Mr. J. B. White.

An association of white sub-translucent quartz with a little greenish-gray chloritic schist, carrying very small quantities of copper-pyrites. Weight of sample, five ounces.

It contained neither gold nor silver.

36.—From the second lot of the third concession of the township of May, district of Algoma.

Consisted of small quantities of copper-pyrites in a black tourmaline rock. Weight of sample, four ounces.

It contained neither gold nor silver.

37.—From about one and a half mile north of the Moncrieff township line, district of Algoma.

A white sub-translucent quartz, more or less stained with hydrated peroxide of iron, carrying small quantities of iron and copper-pyrites. Weight of sample, two pounds one ounce.

It contained neither gold nor silver.

38.—From the same locality as the preceding specimen.

An association of white sub-translucent quartz with some green chloritic schist, carrying small quantities of iron-pyrites and a very little copper-pyrites. It was, in parts, stained and coated with hydrated peroxide of iron. Weight of sample, two pounds three ounces.

It contained neither gold nor silver.

39.—From the north-half of lot six, concession two, of the township of Falconbridge, district of Nipissing. This, and the following specimen, were examined for Mr. M. J. O'Brien.

Gold and silver assays, *cont.*

Province of Ontario, *cont.*

A bluish and grayish-white sub-translucent quartz, in parts coated with hydrated peroxide of iron and green carbonate of copper, carrying small quantities of copper-pyrites. Weight of sample, fifteen ounces. Assays gave:

Gold .... 0·117 of an ounce to the ton of 2,000 lbs.
Silver............ none.

40.—From the south-half of lot two, concession four, of the township of Blezard, district of Nipissing.

An association of white sub-translucent quartz with a little felspar and mica-schist, in parts coated with hydrated peroxide of iron and a little green carbonate of copper, carrying very small quantities of copper-pyrites. Weight of sample, one pound eight ounces.

It contained neither gold nor silver.

41.—From lots six and seven of the third concession of the township of Davis, district of Nipissing. Examined for Mr. Placide Rousseau.

A grayish to white opaque quartz, stained and coated with hydrated peroxide of iron, carrying small quantities of iron and copper-pyrites. Weight of sample, eleven ounces.

It contained neither gold nor silver.

42.—From lots thirteen and fourteen, concession two, of the township of Davis, district of Nipissing.

The material consisted of a grayish-white sub-translucent quartz, more or less stained with hydrated peroxide of iron; and a fine-crystalline galena. This material was assayed separately. The quartzose portion of the same, contained no trace of either gold or silver; the galena, however, was found to contain:

Gold................. none.
Silver................ 48·854 ounces to the ton of 2,000 lbs.

43.—From the twenty-fifth lot of the third concession of the township of Hagerman, Parry Sound district.

A garnetiferous gneiss carrying small quantities of copper-pyrites. Weight of sample, four pounds eleven ounces.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of Ontario, *cont.*

44.—From twenty-eight miles west of Port Arthur, Thunder Bay district.

An association of a dark gray crypto-crystalline, and a white sub-translucent quartz, in parts coated with hydrated peroxide of iron, through which were disseminated numerous fine particles of iron-pyrites. Weight of sample, two pounds six ounces. It contained :

Gold	trace.
Silver	none.

45.—From Rat Portage, Rainy River district. This, and the four following specimens, were examined for Mr. J. F. Torrance.

An association of grayish to reddish-white sub-translucent quartz with a little grayish-green fine grained diorite, carrying a very small quantity of iron-pyrites. Weight of sample, five ounces.

It contained neither gold nor silver.

46.—From the same locality as the preceding specimen.

A somewhat weathered, gray gneissoid rock, carrying small quantities of iron-pyrites. Weight of sample, seven ounces. Assays showed it to contain :

Gold	trace.
Silver	none.

47.—Also from Rat Portage, district of Rainy River.

A somewhat weathered, gray gneissoid rock, through which was disseminated a little iron-pyrites. Weight of sample, four ounces.

It contained neither gold nor silver.

48.—From a vein south of Rossland, Rainy River district.

White and reddish-white sub-translucent quartz, carrying small quantities of iron-pyrites. Weight of sample, five ounces. Assays gave :

Gold	trace.
Silver	none.

49.—From the same locality as the preceding specimen.

The material consisted of very finely powdered, white rock matter. Weight of sample, two ounces and a half. It contained :

Gold	trace.
Silver	none.

Gold and silver assays, *cont.*

Province of Ontario, *cont.*

50.—From mining location K. 231, Rainy River district. This, and the three following specimens, were examined for Mr. W. A. Allan.

A white sub-translucent quartz, stained and coated with hydrated peroxide of iron, through which were disseminated a few specks of iron-pyrites. Weight of sample, four pounds. It was found to contain :

Gold	trace.
Silver	none.

51.—From mining location K. 241, Rainy River district.

An association of white sub-translucent quartz, with a light gray steatite. The material, which was much stained and coated with hydrated peroxide of iron, weighed five pounds thirteen ounces. Assays gave :

Gold	trace.
Silver	none.

52.—From a location on Seine River, district of Rainy River.

An association of white and gray sub-translucent quartz with a white to dark gray gneissoid rock and green to greenish-gray chloritic schist, carrying small quantities of iron and copper-pyrites. Weight of sample, five pounds ten ounces. It contained :

Gold	trace.
Silver	none.

53.—From a vein near Shoal Lake, district of Rainy River.

An association of white sub-translucent quartz with some white felspar and small quantities of hornblendic and chloritic schists, carrying small amounts of iron and copper-pyrites. Weight of sample, two pounds six ounces.

It contained neither gold nor silver.

Province of Manitoba.

Province of Manitoba.

54.—From Lac du Bonnet, Winnipeg River. This, and the four following specimens, were examined for Mr. E. F. Stephenson.

An association of pyrrhotite with small quantities of iron-pyrites, in a gangue of greenstone. Weight of sample, two pounds eight ounces.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of Manitoba, *cont.*

55.—From the east shore of Lac du Bonnet, Winnipeg River.

An association of a dark-gray quartz with a dark gray chloritic schist, carrying large quantities of iron-pyrites. Weight of sample, two pounds six ounces.

It contained neither gold nor silver.

56.—From the same locality as the preceding specimen.

A grayish crypto-crystalline quartz, in parts stained with hydrated peroxide of iron, through which were disseminated a few grains of iron-pyrites. Weight of sample, thirteen ounces. It contained :

Gold	trace.
Silver	none.

57.—Also from the east shore of Lac du Bonnet, Winnipeg River.

A siliceous sand containing more or less rounded fragments of quartz and limestone and a few intermixed particles of pyrite.

It contained neither gold nor silver.

58.—Another rock specimen from the last mentioned locality.

Consisting of a dark-gray chloritic schist, through which were disseminated a few grains of iron-pyrites, was submitted to assay and found—

To contain neither gold nor silver.

North-west Territory.

North-west Territory.

59.—From Deer River. Collected by Mr. D. B. Dowling.

A somewhat fine-grained granitic gneiss, through which were disseminated numerous fine grains of pyrrhotite. Weight of sample, one pound one ounce.

It contained neither gold nor silver.

60.—From Lake Athabasca. Collected by Mr. J. B. Tyrrell.

Quartz, stained and coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites. Weight of sample, one pound four ounces. It was found to contain :

Gold	none.
Silver	0·933 of an ounce to the ton of 2,000 lbs.

61.—From township nine, range two, west of the fifth meridian. Examined for Mr. W. Pearce.

Gold and silver assays, *cont.*

North-west Territory, *cont.*

A very fine-grained conglomerate, in parts coated with hydrated peroxide of iron. Weight of sample, two pounds seven ounces.

It contained neither gold nor silver.

62.—From a claim in the Bow River valley, near the summit of the Rocky Mountains, about three miles from Laggan station and two miles from the line of the Canadian Pacific Railway. Examined for Mr. P. McCarthy.

An association of white sub-translucent quartz and siderite, carrying small quantities of galena and iron-pyrites. Weight of sample, eleven ounces.

It contained neither gold nor silver.

63.—From a ledge on north side of cañon, eighteen miles above Pelly Lake, Yukon district. Collected by Mr. Warburton Pike.

Yukon district.

A gray crypto-crystalline quartz, carrying some iron-pyrites. Weight of sample, two ounces.

It contained neither gold nor silver.

64.—From the Yukon River, eighteen miles above Forty-mile Creek, Yukon district. This, and the three following specimens were collected by Mr. Charles Constantine.

Quartz, stained with blue and green carbonate of copper, carrying small quantities of tennantite and copper-pyrites. Weight of sample, five ounces. It was found to contain :

Gold............. none.
Silver............ 0·233 of an ounce to the ton of 2,000 lbs.

65.—Clondyke Creek, Yukon River, eighteen or twenty miles above Forty-mile Creek, Yukon district.

Quartz, stained and coated with blue and green carbonate of copper, containing, here and there, a little copper-pyrites.

It contained neither gold nor silver.

66.—From the same locality at the preceding specimen.

A grayish-white to white, crypto-crystalline quartz, carrying small quantities of iron-pyrites, galena, and zinc-blende. Weight of sample, one pound. Assays gave :

Gold............. none.
Silver............ 0·525 of an ounce to the ton of 2,000 lbs.

Gold and silver assays, *cont.*

Yukon district, *cont.*

67.—From Porcupine Creek, Yukon River, thirty miles above Fortymile Creek, Yukon district.

White sub-translucent quartz, in parts stained and coated with green carbonate of copper, carrying somewhat large quantities of copper-pyrites and a little bornite. Weight of sample, thirteen ounces.

It contained neither gold nor silver.

68.—From Stewart River, Yukon district.

Quartz, carrying small quantities of iron-pyrites. Weight of sample, five ounces.

It contained neither gold nor silver.

Province of British Columbia.

Of the following—

Specimens Nos.	69— 71	are from the	East Kootanie district.
"	72— 75	"	West Kootanie district.
"	76—104	"	Interior plateau region.
"	105—108	"	Coast ranges and coast region.

(Specimens Nos. 82-97 inc., were collected by Dr. G. M. Dawson; Nos. 98-102 inc., by Mr. J. McEvoy.)

Province of British Columbia.

East Kootanie district.

69.—From a ledge near the head of St. Mary's River, East Kootanie district. Examined for Mr. J. J. Driscoll.

A white, opaque quartz, carrying small quantities of galena and iron-pyrites. Weight of sample, somewhat less than an ounce.

It contained neither gold nor silver.

70.—From Sand Creek, Kootanie River, about twenty-six miles south of Fort Steele, East Kootanie district.

An association of a white sub-translucent quartz with a little pale salmon-coloured felspar, more or less coated with hydrated peroxide of iron, carrying small quantities of galena and copper-pyrites. Weight of sample, ten ounces. Assays gave :

Gold.................. none.
Silver................ 4·667 ounces to the ton of 2,000 lbs.

71.—From about one hundred feet north of the last mentioned locality.

Consisted of iron-pyrites with a little white, sub-translucent quartz. Weight of sample, one pound. It was found to contain :

Gold............. 0·175 of an ounce to the ton of 2,000 lbs.
Silver............ 0·875 " " "

72.—From a ledge on the south side of the Kootanie River, west of Nelson, West Kootanie district. Examined for Mr. J. J. Driscoll.

Gold and silver assays, *cont.*

Province of British Columbia, *cont.*

West Kootanie district.

A dark-gray, hornblendic gneissoid rock, carrying some iron-pyrites, copper-pyrites and a little pyrrhotite. Weight of sample, five pounds. It contained :

Gold	trace.
Silver	1·400 ounce to the ton of 2,000 lbs.

73.—From near the head of South Carpenter Creek, West Kootanie district. Examined for Mr. A. D. Wilson.

An association of white calcite and black chloritic schist, carrying some zinc-blende and iron-pyrites. Weight of sample, nine ounces. Assays gave :

Gold	trace.
Silver	5·133 ounces to the ton of 2,000 lbs.

74.—From an unnamed creek flowing into Downie Creek, about twenty miles above its entry into the Columbia River, West Kootanie district. This, and the following specimen, were examined for Mr. J. D. Boyd.

A dark-gray quartzo-felspathic rock, through which was disseminated a somewhat large amount of pyrrhotite. Weight of sample, ten ounces.

It contained neither gold nor silver.

75.—From Carnes Creek, Columbia River, about twenty miles north of Revelstoke, West Kootanie district.

Consisted of mispickel in a gangue of quartz which was, in parts, coated with hydrated peroxide of iron. Weight of sample, twelve ounces. It contained :

Gold	0·525 of an ounce to the ton of 2,000 lbs.
Silver	none.

76.—From Pass Creek, Adams Lake, Interior plateau region.

Interior plateau region.

A coarsely crystalline galena, through which was disseminated a somewhat large amount of white sub-translucent quartz. The galena, freed from all gangue, was found on assay to contain :

Gold	none.
Silver	133·437 ounces to the ton of 2,000 lbs.

77.—From Clinton, Interior plateau region.

A very dark-gray quartz traversed by thin bands of white and light gray quartz, in parts seamed and coated with hydrated peroxide of iron, with, here and there, a few specks of pyrite. Weight of sample, eleven ounces.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of British Columbia, *cont.*

Interior plateau region, *cont.*

78.—From Copper Creek, Boundary Creek, Interior plateau region.

An association of quartz, chalcocite and green, with more rarely a little blue, carbonate of copper. Weight of sample, six ounces. It contained:

Gold	none.
Silver	2·158 ounces to the ton of 2,000 lbs.

79.—From Watson Bar Creek, north fork, fifteen miles west of Fraser River, Interior plateau region.

Pyrrhotite together with a little black zinc-blende and a very little copper-pyrites, in a gangue consisting of a white dolomitic limestone with a little quartz. The sample, which was, in parts, coated with hydrated peroxide of iron, weighed five ounces. Assays gave:

Gold	0·583 of an ounce to the ton of 2,000 lbs.
Silver	0·933 " "

80.—From the vicinity of the Glen Iron Mine, Cherry Bluff, Kamloops Lake, Interior plateau region.

A highly weathered rock, coated with green carbonate of copper. Weight of sample, seven ounces.

It contained neither gold nor silver.

81.—From the same locality as the preceding specimen.

A white sub-translucent quartz, stained and coated with ferric hydrate, carrying small quantities of iron-pyrites. Weight of sample, fifteen ounces.

It contained neither gold nor silver.

82.—From In-koi-ko Creek, Fraser River, Interior plateau region.

A considerably metamorphosed greenish-gray rock, with here and there a few particles of iron- and copper-pyrites. Weight of sample, twelve ounces. It contained.

Gold	trace.
Silver	none.

83.—From Duffy Creek, near Kamloops Lake, Interior plateau region.

An association of a reddish-gray quartz with a grayish-white dolomite. Weight of sample, seven ounces. Assays showed it to contain:

Gold	trace.
Silver	none.

84.—From the west side of Thompson River, opposite Spatsum station, Interior plateau region.

Gold and silver assays, *cont.*

Province of British Columbia, *cont.*

Interior plateau region, *cont.*

An association of a gray felspathic rock with gypsum, through which were disseminated numerous small specks of iron-pyrites. Weight of sample, twelve ounces.

It contained neither gold nor silver.

85.—From three miles and a half north of Spatsum, Interior plateau region.

A gray, quartzo-felspathic rock, in parts coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites. Weight of sample, ten ounces.

It contained neither gold nor silver.

86.—From Alkali Creek, south-west of Kamloops, Interior plateau region.

A white sub-translucent quartz, in parts coated with hydrated peroxide of iron, and containing a few specks of iron-pyrites. Weight of sample, twelve ounces.

It contained neither gold nor silver.

87.—From Shuswap Lake, a third of a mile north of Cape Horn, Interior plateau region.

A white sub-translucent quartz, in parts stained and coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites. Weight of sample, three pounds ten ounces.

It contained neither gold nor silver.

88.—From a zone of pyritous schists, Shuswap Lake, Interior plateau region.

An association of a weathered mica-schist and white dolomitic sandstone. Weight of sample, two pounds two ounces.

It contained neither gold nor silver.

89.—From near wagon-road, one mile north of Jack's Creek, Interior plateau region.

A yellowish-white argillaceous earth. Weight of sample, one pound.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of British Columbia, *cont.*

Interior plateau region, *cont.*

90.—From half a mile north of Cinnemousun Narrows, Shuswap Lake, east side of point, Interior plateau region.

An association of quartz, felspar and mica, more or less stained and coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites. Weight of sample, two pounds.

It contained neither gold nor silver.

91.—From a zone of pyritous schists, Copper Island, Shuswap Lake, Interior plateau region.

A schistose rock, stained and coated with hydrated peroxide of iron and green carbonate of copper, carrying small quantities of copper-pyrites. Weight of sample, one pound twelve ounces. It contained :

Gold............ trace.
Silver........... 0·233 of an ounce to the ton of 2,000 lbs.

92.—From a vein upon which prospect holes have been opened, Shuswap Lake, Interior plateau region.

A white sub-translucent quartz, more or less stained and coated with hydrated peroxide of iron, carrying somewhat large quantities of zinc-blende, pyrrhotite and iron-pyrites. Weight of sample, one pound ten ounces. Assays gave :

Gold .... trace.
Silver................ 1·342 ounce to the ton of 2,000 lbs.

93.—From large irregular veins on Shuswap Lake, Interior plateau region.

An impure dolomitic limestone, through which was disseminated a little iron-pyrites. Weight of sample, two pounds two ounces.

It contained neither gold nor silver.

94.—From a quarter of a mile west of Cape Horn, north side of Shuswap Lake, Interior plateau region.

A white crypto-crystalline quartz, in parts stained and coated with hydrated peroxide of iron, carrying small quantities of iron-pyrites. Weight of sample, two pounds twelve ounces.

It contained neither gold nor silver.

95.—From point, outer side of Blind Bay, Shuswap Lake, Interior plateau region.

A white sub-translucent to opaque quartz, in parts stained and coated with hydrated peroxide of iron, with, here and there, a little iron pyrites.

Weight of sample, three pounds fourteen ounces. It contained: Gold and silver assays, *cont.*

Gold	trace.
Silver	none.

Province of British Columbia, *cont.*

Interior plateau region, *cont.*

96.—From a mile south of Cinnemousun Narrows, east side of point, Shuswap Lake, Interior plateau region.

A somewhat fine-grained, slightly weathered granite, containing a few specks of iron-pyrites. Weight of sample, fifteen ounces.

It contained neither gold nor silver.

97.—From road-cutting about a mile from Quesnel Forks, Interior plateau region.

A cherty conglomerate. Weight of sample, one pound seven ounces.

It contained neither gold nor silver.

98.—From two and a half miles south-east of Duck's station, Interior plateau region.

A weathered rock. Weight of sample, one pound two ounces.

It contained neither gold nor silver.

99.—From 323-mile post on the line of the Canadian Pacific railway, between Sicamous and Salmon Arm, Shuswap Lake, Interior plateau region.

A white quartzo-felspathic rock, though which were disseminated numerous fine specks of pyrite Weight of sample, fourteen ounces.

It contained neither gold nor silver.

100.—From Sicamous station, on the line of the Canadian Pacific railway, Interior plateau region.

An association of a somewhat coarsely crystalline white limestone with a white sub-translucent quartz, containing, in parts, a few particles of iron-pyrites. Weight of sample, one pound four ounces.

It contained neither gold nor silver.

101.—From the North Fork of Edward's Creek, five miles above forks, North Thompson River, Interior plateau region.

A fine to coarse-grained quartzo-felspathic rock, stained with hydrated peroxide of iron, carrying a little iron-pyrites. Weight of sample, one pound eleven ounces.

It contained neither gold nor silver.

Gold and silver assays, *cont.*

Province of British Columbia, *cont.*

Interior plateau region, *cont.*

102.—From Scotch Creek, two miles below forks, Shuswap Lake, Interior plateau region.

A mottled, gray and brownish-black gneissoid rock, in parts incrusted with a little carbonate of lime and more or less stained and coated with hydrated peroxide of iron, carrying a little iron-pyrites. Weight of sample, one pound thirteen ounces.

It contained neither gold nor silver.

103.—From Harry's Creek, twenty miles east of the city of Vernon, Interior plateau region. This, and the following specimen, were examined for Mr. Forbes M. Kerby.

A white sub-translucent quartz, more or less stained with hydrated peroxide of iron, carrying small quantities of galena. Weight of sample, four ounces. It was found to contain :

Gold	distinct trace.
Silver	54·367 ounces to the ton of 2,000 lbs.

104.— From the same locality as the preceding specimen.

Crushed rock matter, consisting of quartz and galena. It contained :

Gold	distinct traces.
Silver	204·167 ounces to the ton of 2,000 lbs.

Coast ranges and coast region.

105.—From a vein some five feet wide, about five miles up Silver Creek, near Hope, Fraser River, Coast ranges and Coast region. Examined for A. N. York & Co.

An association of white sub-translucent to opaque quartz with a small quantity of greenish-gray chloritic-schist and a little kaolin. Weight of sample, fourteen ounces.

It contained neither gold nor silver.

106.—From Jarvis Inlet, Coast ranges and Coast region. Examined for Mr. C. F. Law.

A granitic rock, composed of white quartz, white felspar, black mica, and a little greenish-yellow epidote. Weight of sample, eight pounds thirteen ounces.

It contained neither gold nor silver.

107.—Also from Jarvis Inlet, Coast ranges and Coast region.

Consisted of pyrrhotite, together with some chalcopyrite and a very little galena, in a gangue composed of an association of gray quartz with a fine-grained diorite. Weight of sample, three pounds seven ounces. It was found to contain :

Gold	none.
Silver	4·725 ounces to the ton of 2,000 lbs.

108.—From a mile and a half east of Chilliwack, Coast ranges and Coast region. Examined for Mr. T. Vance. Gold and silver assays, *cont.*

There were two distinct samples—the one consisting of a dark gray to white sub-translucent quartz, carrying small quantities of iron-pyrites and zinc-blende; the other of an association of grayish-white crypto-crystalline quartz with a dark-gray chloritic-schist and a little altered felspar, carrying very small quantities of iron-pyrites. A fair average sample prepared from the two, contained: Coast ranges and coast region, *cont.*

Gold.............	trace.
Silver............	0·408 of an ounce to the ton of 2,000 lbs.

109.—From China Creek, Alberni, Vancouver Island.

A grayish-white to dark gray quartz, carrying small quantities of iron-pyrites and a little galena. Weight of sample, fifteen ounces. It was found to contain:

Gold.............	0·117 of an ounce to the ton of 2,000 lbs.
Silver........ ...	0·817 " "

110.—From the Golden Eagle claim, China Creek, Alberni, Vancouver Island.

An average sample of fifty pounds of the crushed vein material. A fine, dark gray powder. This, on assay, was found to contain:

Gold...................	1·225 ounce to the ton of 2,000 lbs.
Silver.....	0·525 " "

NATURAL WATERS.

The analyses of these, were all conducted by Mr. F. G. Wait.

1.—Water from the boring at Athabasca Landing, district of Alberta, North-west Territory. Collected September 1st, 1895. Water from boring at Athabasca Landing, N.W.T.

In this connection, it may be mentioned, that Dr. G. M. Dawson informs me, that in the prosecution of the boring in question, a saline water was struck in the Pelican sandstones, 1090-1130 feet down. The water flowed out at the top of the bore-hole—but not strongly. At the time of collection of the sample for analysis, the bore had reached a depth of 1510 feet and was in the Grand Rapids sandstone. The casing was down 1280 feet, and water from the Pelican sandstones was flowing down round the end of the casing. A small proportion of the water may, therefore, have come from the Grand Rapids sandstones; but, as a whole, it undoubtedly represents the flow from the Pelican sandstones.

Natural waters, *cont.*

Water from boring at Athabasca Landing, N.W.T., *cont.*

The sample received for examination contained a small quantity of suspended matter. This was removed by filtration. The filtered water, which was at first perfectly clear and colourless, became, after standing a short time, turbid and deposited ferric hydrate, with ultimate complete separation of the iron previously contained in the water. It was odourless; taste, strongly saline; reaction, neutral. Its specific gravity, at 15·5° C., was found to be 1027·5. Boiling produced a small precipitate, consisting of ferric hydrate with a little carbonate of lime.

Its analysis gave as follows, for 1000 parts by weight:

Potassa	0·038
Soda	16·988
Lime	0·934
Magnesia	0·468
Ferrous oxide	0·049
Carbonic acid	0·083
Silica	0·008
Chlorine	21·487
Organic matter	traces.
	40·055
Less oxygen, equivalent to chlorine	4·842
	35·213

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination:

(The carbonates being calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	0·060
" sodium	32·058
" calcium	1·834
" magnesium	1·112
Carbonate of lime	0·016
" iron	0·079
Silica	0·008
Organic matter	traces.
	35·167
Carbonic acid, half-combined	0·037
" free	0·009
	35·213

Total dissolved solid matter, by direct experiment, dried at 180° C., 35·122.

An imperial gallon of the water at 15·5° C. would contain:

(The carbonates being calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

Natural waters, *cont.*

Water from boring at Athabasca Landing, N.W.T., *cont.*

	Grains.
Chloride of potassium	4·32
" sodium	2305·77
" calcium	131·91
" magnesium	79·98
Bi-carbonate of lime	1·65
" iron	7·84
Silica	0·57
Organic matter	traces.
	2532·04
Carbonic acid, free	0·65
	2532·69

The water was examined for, and found to contain—a very distinct trace of lithium, faint traces of barium and strontium, also very distinct traces of bromine and a very strong trace of iodine.

Water from a spring in Carp village, Carleton Co., Ont.

2.—From a spring in Carp village, lot eighteen, concession three, of the township of Huntley, Carleton county, province of Ontario.

The sample of water sent for examination, was perfectly clear and bright, colourless, odourless and devoid of any marked taste; reaction, neutral. Specific gravity, at 15·5° C., 1000·43. Boiling produced a somewhat copious precipitate, consisting of carbonate of lime with some carbonate of magnesia.

An analysis showed it to contain—in 1000 parts, by weight:

Potassa	0·005
Soda	0·021
Lime	0·084
Magnesia	0·024
Sulphuric acid	0·019
Carbonic acid	0·186
Silica	0·031
Chlorine	0·011
	0·381
Less oxygen, equivalent to chlorine	0·002
	0·379

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination:

(The carbonates being calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Natural waters, *cont.*

Water from a spring in Carp village, Carleton Co., Ont., *cont.*

Chloride of sodium	0·018
Sulphate of potassa	0·009
" soda	0·027
Carbonate of lime	0·150
" magnesia	0·050
Silica	0·031
	0·285
Carbonic acid, half-combined	0·092
" free	0·002
	0·379

An imperial gallon of the water, at 15·5° C., would contain:

(The carbonates being calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

	Grains.
Chloride of sodium	1·26
Sulphate of potassa	0·63
" soda	1·89
Bi-carbonate of lime	15·13
" magnesia	5·32
Silica	2·17
	26·40
Carbonic acid, free	0·14
	26·54

Alumina, iron and organic matter were sought for, and found to be absent.

Water from a spring at Salina, King's Co., N.B.

3.—Water from salt-spring at Salina, King's county, province of New Brunswick. Collected by Mr. R. Chalmers, July, 1895.

It was found to contain a small quantity of brown, flocculent, organic matter in suspension. This was removed by filtration, leaving the water clear and colourless. Specific gravity, at 15·5° C., 1018·5. It contained in 1,000 parts, by weight:

Potassa	0·177
Soda	9·614
Lime	1·549
Magnesia	0·185
Sulphuric acid	2·319
Chlorine	11·379
	25·223
Less oxygen, equivalent to chlorine	2·564
	22·659

Natural waters, *cont.*

Water from a spring at Salina, King's Co., N.B., *cont.*

Hypothetical combination :

Chloride of potassium	0·280
" sodium	18·145
" magnesium	0·313
Sulphate of lime	3·762
" magnesia	0·159
	22·659

Total dissolved solid matter, by direct experiment, dried at 180° C., 22·605.

An imperial gallon of the water, at 15·5° C., would contain :

	Grains.
Chloride of potassium	19·963
" sodium	1293·648
" magnesium	22·315
Sulphate of lime	268·212
" magnesia	11·336
	1615·474

The quantity of the water at the disposal of the operator was too limited to admit of its being examined for other than the above mentioned constituents.

Water from a boring at Sussex Station, King's Co., N.B.

4.—Water from a boring some 1,500 feet south-east of Sussex Station, on the line of the Intercolonial Railway, King's county, province of New Brunswick. Received from S. H. White & Co., of Sussex, N.B.

The sample of this water received for examination, was found to be somewhat turbid. After filtration, it proved to be colourless, odourless and devoid of any marked taste. Reaction, faintly alkaline; when evaporated to a small volume, very markedly so. Specific gravity, at 15·5° C., 1000·44. Boiling produced no precipitate.

Agreeably with the results of analysis, it contained in 1,000 parts, by weight:

Potassa	0·002
Soda	0·237
Lime	0·003
Magnesia	trace.
Ferrous oxide	trace.
Sulphuric acid	0·012
Carbonic acid	0·284
Silica	0·015
Chlorine	0·019
	0·572
Less oxygen, equivalent to chlorine	0·004
	0·568

Natural waters, *cont.*

Water from a boring at Sussex Station, King's Co., N.B., *cont.*

The foregoing acids and bases are most probably combined in the water as follows :

(Carbonates calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	0·003
" sodium	0·030
Sulphate of soda	0·021
Carbonate of soda	0·362
" lime	0·005
Silica	0·015
	0·436
Carbonic acid, half-combined	0·132
	0·568

Total dissolved solid matter, by direct experiment, dried at 180° C., 0·390.

There was not enough of the water at the disposal of the operator to admit of its being examined for other than the above-mentioned constituents.

Water from artesian well at Fish-hatchery, Selkirk, Man.

5.—Water from artesian well at the Fish-hatchery, Selkirk, province of Manitoba.

The boring was, as I am informed, by Mr. D. B. Dowling, carried to a depth of three hundred feet below the surface of the ground at the hatchery, or two hundred and eighty-four feet below the level of the Red River. The water is derived from shales and sandy beds below the limestone, and these are probably the representatives of the upper part of the Winnipeg sandstone (St. Peters). Temperature of the water in the well, 42·5° F.

The sample supplied for analysis was perfectly clear, colourless and bright; odourless; taste, mildly saline; reaction, neutral, both before and after concentration. Specific gravity, at 15·5° C., 1002·56. It contained in 1,000 parts, by weight:

Potassa	0·036
Soda	1·338
Lime	0·145
Magnesia	0·121
Iron and alumina	trace.
Sulphuric acid	0·286
Carbonic acid	0·430
Silica	0·009
Chlorine	1·434
	3·799
Less oxygen, equivalent to chlorine	0·323
	3·476

Natural waters, *cont.*

Water from artesian well at Fish hatchery, Selkirk, Man., *cont.*

It may be reasonably assumed that the foregoing acids and bases exist in the water in the following state of combination :

(Carbonates calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of sodium	2·363
Sulphate of potassa	0·067
" soda	0·196
" lime	0·247
Carbonate of lime	0·077
" magnesia	0·255
Silica	0·009
	3·214
Carbonic acid, half-combined	0·167
" free	0·095
	3·476

Total dissolved solid matter, by direct experiment, dried at 180° C., 3·160.

An imperial gallon of the water, at 15·5° C., would contain :

(Carbonates calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

	Grains.
Chloride of sodium	165·812
Sulphate of potassa	4·695
" soda	13·790
" lime	17·334
Bi-carbonate of lime	7·776
" " magnesia	27·215
Silica	0·653
	237·275
Carbonic acid, free	6·695
	243·970

The quantity of the water at the disposal of the operator, was too limited to allow of his examining it for any of the more rarely occurring constituents.

6.—Water from the 'Alpha' spring, Diamond Park Mineral Springs, lot twenty-six of the twelfth concession of the township of Pakenham, Lanark county, province of Ontario. Collected by Mr. J. A. McDonald, September 18th, 1893.

Water from the 'Alpha' spring, Pakenham, Lanark Co., Ont.

The sample received for analysis contained a very trifling amount of a pale brownish-yellow coloured sediment. This was removed by filtration. The filtered water was colourless, or nearly so, exhibiting but a faint brownish-yellow tinge when viewed in a column two feet in length. It was odourless ; taste, mildly saline ; reaction, neutral—when concentrated to a small volume, however, distinctly alkaline. Specific gravity, at 15·5° C., 1003·76.

Natural waters, *cont.*

Water from the 'Alpha' spring, Pakenham, Lanark Co., Ont., *cont.*

An analysis showed it to contain—in 1000 parts, by weight :

Potassa	0·042
Soda	2·269
Lime	0·083
Magnesia	0·165
Iron and alumina	0·001
Sulphuric acid	0·021
Carbonic acid	0·670
Silica	0·024
Chlorine	2·532
Organic matter	traces.
	5·807
Less oxygen, equivalent to chlorine	0·571
	5·236

The foregoing acids and bases may reasonably be assumed to be present in the water in the following state of combination :

(Carbonates calculated as mono-carbonates, and all the salts estimated as anhydrous.)

Chloride of potassium	0·067
" sodium	4·120
Sulphate of soda	0·037
Carbonate of soda	0·120
" lime	0·148
" magnesia	0·346
Iron and alumina	0·001
Silica	0·024
Organic matter	traces.
	4·863
Carbonic acid, half-combined	0·296
" free	0·077
	5·236

Total dissolved solid matter, by direct experiment, dried at 180° C., 4·706.

An imperial gallon of the water, at 15·5° C., would contain :

(Carbonates calculated as anhydrous bi-carbonates, and the salts without their water of crystallisation.)

	Grains.
Chloride of potassium	4·729
" sodium	289·463
Sulphate of soda	2·572
Bi-carbonate of soda	11·917
" lime	14·994
" magnesia	37·099
Iron and alumina	0·042
Silica	1·693
Organic matter	traces.
	362·509
Carbonic acid, free	5·403
	367·912

Natural waters, *cont.*

The water contains traces of iodine but no bromine, nor was any evidence obtained of the presence of either lithium, barium or strontium.

Water from a spring near New Town, Lunenburg, Co., N.S.

7.—Water from a spring near New Town, Lunenburg county, province of Nova Scotia. Examined for Mr. J. A. Hirtle.

The water, as received, contained a trifling amount of brown, flocculent, organic matter. This was removed by filtration. The filtered water was bright, almost colourless, odourless, and devoid of any marked taste. Reaction, neutral—when concentrated to a small volume, faintly alkaline. It was found to have a specific gravity, at 15·5° C., of 1000·02, and to contain only 0·06 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water—equivalent to 4·20 grains per imperial gallon.

A qualitative analysis showed it to contain:

Soda	very small quantity.
Lime	small quantity.
Magnesia	decided traces.
Sulphuric acid	very small quantity.
Carbonic acid	very small quantity.
Chlorine	decided traces.
Organic matter	faint traces.

Boiling produced no perceptible precipitate. Potassium and lithium were sought for and not detected.

Water from a spring in St. Stephen, Charlotte Co., N.B.

8.—Water from a spring in the parish of St. Stephen, Charlotte county, province of New Brunswick. Examined for Mr. J. S. Andrews.

It was colourless and odourless; devoid of any marked taste; reaction, neutral. The total dissolved solid matter, dried at 180° C., in 1000 parts, by weight, of the water, amounted to 0·114 parts, or 7·98 grains per imperial gallon.

It was found to contain:

Soda	traces.
Lime	small quantity.
Sulphuric acid	very small quantity.
Carbonic acid	very small quantity.
Chlorine	traces.
Silica	traces.
Organic matter	very small quantity.

Boiling produced a very slight precipitate consisting of carbonate of lime. Potassium, lithium and magnesium were found to be absent.

Natural waters, *cont.*

Water from ? Megantic Co., Que.

9.—Water from ?, Megantic county, province of Quebec.

The sample sent for examination contained a small quantity of white, flocculent, organic matter in suspension—this was removed by filtration. The filtered water was bright, colourless, odourless and devoid of any marked taste. Reaction, neutral—when concentrated to a small volume, faintly alkaline. It contained 0·154 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water—equivalent to 10·78 grains per imperial gallon.

It contained :

Soda	very small quantity.
Lime	small quantity.
Magnesia	traces.
Sulphuric acid	very small quantity.
Carbonic acid	rather small quantity.
Chlorine	strong traces.
Organic matter	faint traces.

Boiling produced a slight precipitate, consisting chiefly of carbonate of lime.

Water from a spring at St. Benoit, county of Two Mountains, Que.

10.—Water from a spring in the village of St. Benoit, county of Two Mountains, province of Quebec. Examined for Mr. A. Dumouchel.

The sample sent, contained a trifling amount of white, flocculent, organic matter in suspension, which was removed by filtration, leaving the water bright and colourless, It was devoid of odour. Taste, mildly saline. Reaction, neutral. Specific gravity (by hydrometer), at 15·5° C., 1004. The total dissolved saline matter dried at 180° C., in 1000 parts, by weight, of the water, amounted to 5·11 parts—equivalent to 359·24 grains per imperial gallon.

A qualitative analysis showed it to contain :

Potassa	traces.
Soda	large quantity.
Lime	small quantity.
Magnesia	small quantity.
Sulphuric acid	rather small quantity.
Carbonic acid	very small quantity.
Chlorine	large quantity.
Silica	traces.
Organic matter	traces.

Boiling produced a slight precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

Natural waters, *cont.*

11.—Water from a spring on the grounds of the Hotel des Deux Montagnes, St. Benoit, county of Two Mountains, province of Quebec. Examined for Mr. M. Charbonneau.

Water from a spring at St. Benoit, county of Two Mountains, Que.

The sample received for examination contained a trifling quantity of brownish organic matter in suspension—this was removed by filtration. The filtered water was bright, colourless and odourless. Taste, mildly saline. Reaction, neutral. Specific gravity (by hydrometer), at 15·5° C., 1005. It contained 6·99 parts dissolved saline matter, dried at 180° C., in 1000 parts, by weight—equivalent to 491·75 grains per imperial gallon. It was found to contain :

Potassa	traces.
Soda	large quantity.
Lime	rather small quantity.
Magnesia	rather small quantity.
Sulphuric acid	somewhat large quantity.
Carbonic acid	very small quantity.
Chlorine	large quantity.
Silica	traces.

Boiling produced a very slight precipitate, consisting of carbonates of lime and magnesia, with a trace of sulphate of lime.

12.—Water from the 'Lord' well, in the town of Joliette, Joliette county, province of Quebec. Taken at a depth of one hundred and twenty-five feet from the surface.

Water from the 'Lord' well, Joliette, Joliette Co., Que.

The sample sent for examination was found to be, in a small volume, all but colourless ; when viewed in a column two feet in length, pale greenish-yellow. Taste, insipid. Odour, faintly argillaceous. Reaction, neutral—when evaporated to a small volume, however, alkaline. Specific gravity, at 15·5° C., 1000·51. Total dissolved saline matter, dried at 180° C., 0·4567 parts per 1,000—equivalent to 32 grains in an imperial gallon.

Agreeably with the results of a qualitative analysis it contained :

Potassa	traces.
Soda	somewhat large quantity.
Lime	very small quantity.
Sulphuric acid	small quantity.
Carbonic acid	small quantity.
Chlorine	very small quantity.
Silica	traces.
Organic matter	very small quantity.

Boiling produced but a very slight precipitate.

Natural waters, *cont.*

Water from the 'Bell' well, Joliette, Joliette Co., Que.

13.—Water from the 'Bell' well, in the town of Joliette, Joliette county, province of Quebec. Taken at a depth of seventy-five feet from the surface.

The sample supplied for examination was found to have in a small volume, a faint yellowish and when viewed in a column two feet in length, a pale brownish-yellow colour. It was devoid of any marked odour, and had an insipid taste. Reaction, neutral—when evaporated to a small volume, however, alkaline. The specific gravity, at 15·5° C., was found to be 1000·49. Total dissolved saline matter, dried at 180° C., 0·3855 parts per thousand—equivalent to 27 grains in an imperial gallon.

A qualitative analysis showed it to contain :

Potassa	traces.
Soda	somewhat large quantity.
Lime	very small quantity.
Ferrous oxide	traces.
Sulphuric acid	traces.
Carbonic acid	somewhat small quantity.
Chlorine	very small quantity.
Silica	traces.
Organic matter	very small quantity.

Boiling produced a very slight precipitate, consisting of carbonate of lime.

Water from a well in the township of Toronto, Peel Co., Ont.

14.—Water from a well on the farm of Mr. John Hanna, township of Toronto, Peel county, province of Ontario.

The sample received contained a somewhat large amount of suspended matter, consisting of ferric hydrate and organic matter. This was removed by filtration. The filtered water had a pale greenish-yellow colour; was devoid of any marked odour; possessed a decided bitter-saline taste; reaction, neutral. The total dissolved saline matter amounted to 1043·0 grains per imperial gallon.

It contained :

Soda	large quantity.
Lime	large quantity.
Magnesia	small quantity.
Alumina	traces.
Ferrous oxide	traces.
Sulphuric acid	somewhat large quantity.
Carbonic acid	very small quantity.
Chlorine	very large quantity.
Silica	traces.
Organic matter	somewhat large quantity.

Boiling produced a slight precipitate, consisting of sulphate and carbonate of lime.

Natural waters, *cont*

15.—Water from the vicinity of Charleston Lake, Leeds county, province of Ontario.

Water from near Charleston Lake, Leeds Co., Ont.

The sample received for examination was clear and colourless. Reaction, neutral. It contained 0·3 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight—equivalent to 21 grains per imperial gallon.

A qualitative analysis indicated the presence of :

Potassa	traces.
Soda	very small quantity.
Lime	large quantity.
Magnesia	traces.
Sulphuric acid	rather large quantity.
Carbonic acid	rather large quantity.
Chlorine	very small quantity.
Organic matter	very small quantity.

Boiling produced a somewhat copious precipitate, consisting of carbonate of lime with a little sulphate of lime.

16.—Water from the twenty-second lot of the sixth concession of the township of Escott, Leeds county, province of Ontario. Examined for Mr. W. H. Ferguson.

Water from Escott, Leeds Co., Ont.

It had a very faint brownish-yellow colour ; was devoid of any marked taste, and odourless. The specific gravity, at 15·5° C., was found to be 1000·45. Total dissolved saline matter, dried at 180° C., 0·3518 parts per 1000—-equivalent to 24·64 grains per imperial gallon.

It was found to contain :

Soda	traces.
Lime	somewhat large quantity.
Magnesia	traces.
Sulphuric acid	small quantity.
Carbonic acid	somewhat small quantity.
Chlorine	traces.
Organic matter	traces.

Boiling produced a very slight precipitate, consisting of carbonate of lime with a very little sulphate of lime.

17.—Water from a hot spring (temperature, about 150° F.), Sinclair Pass, East Kootanie district, province of British Columbia. Examined for Mr. Thomas B. H. Cochrane.

Water from a hot spring, Sinclair Pass, B.C.

The sample received for examination, was found to contain a small quantity of suspended matter, consisting of organic matter

Natural waters, *cont.*
Water from a hot spring, Sinclair Pass, B.C., *cont.*

with traces of ferric hydrate. The filtered water had a faint brownish colour ; was devoid of any marked odour or taste, and reacted neutral—both before and after concentration. It was found to have a specific gravity, at 15·5° C., of 1000·77, and to contain 0·687 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight of the water or 48·16 grains per imperial gallon.

A qualitative analysis showed it to contain :

Potassa	trace.
Soda	small quantity.
Lime	somewhat large quantity.
Magnesia	very small quantity.
Ferrous oxide	traces.
Sulphuric acid	small quantity.
Carbonic acid	small quantity.
Chlorine	very small quantity.
Silica	traces.
Organic matter	traces.

Boiling produced a somewhat small precipitate, consisting mainly of carbonate of lime with a little carbonate of magnesia.

Water from a spring in Kamloops, B.C.

18.—Water from a spring in Kamloops, district of Yale, province of British Columbia. Examined for Mr. J. W. McKay.

The sample forwarded for examination contained a somewhat small quantity of brownish-black flocculent matter, which was found to consist of organic matter with a little sulphide of iron. The filtered water, which was colourless, had a decided, although not strong, odour of sulphuretted hydrogen. It was found to have a specific gravity, at 15·5° C., of 1000·58, and to contain 0·337 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water or 23·60 grains per imperial gallon.

A qualitative analysis indicated the presence of :

Soda	very small quantity.
Lime	somewhat large quantity.
Magnesia	traces.
Sulphuric acid	small quantity.
Carbonic acid	small quantity.
Chlorine	traces.
Organic matter	small quantity.

Boiling produced a precipitate which consisted almost exclusively of carbonate of lime. The sulphuretted hydrogen observable in the water at the time of its receipt, may be ascribed to the reducing action of the organic matter which it contained, on the sulphate or sulphates present in it, in the interval, somewhat lengthy, of its collection and receipt.

19.—This, and the two following waters, are from springs near Grand Prairie, about sixteen miles from Duck's station, on the line of the Canadian Pacific railway, Yale district, province of British Columbia. They were examined for Mr. G. B. Biancotto. Natural waters, *cont.* Water from a spring near Grande Prairie, B.C.

It was bright, odourless and devoid of any marked taste. Viewed in a column two feet in length, it was found to have a faint brownish-yellow colour. Reaction, neutral—when concentrated to a small volume, however, markedly alkaline. It was found to have a specific gravity, at 15·5° C., of 1000·76, and to contain 0·536 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water, or 37·5 grains in the imperial gallon.

A qualitative analysis showed it to contain :

Potassa	faint traces.
Soda	small quantity.
Lime	small quantity.
Magnesia	small quantity.
Ferrous oxide	faint traces.
Sulphuric acid	very small quantity.
Carbonic acid	rather large quantity.
Chlorine	faint traces.
Silica	traces.
Organic matter	traces.

Boiling produced a slight precipitate, consisting of carbonate of lime with some carbonate of magnesia and a very little sulphate of lime.

20.—From the same locality as the preceding water. Water from a spring near Grande Prairie, B.C.

This water, when viewed in a column two feet in length, was found to have a faint greenish-yellow tinge. It was inodorous and devoid of any special taste. Reaction, neutral—when reduced to a small volume, however, faintly alkaline. It was found to have a specific gravity, at 15·5° C., of 1000·38, and to contain 0·374 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water, or 26·2 grains per imperial gallon.

Agreeably with the results of a qualitative analysis, it contained :

Potassa	faint traces.
Soda	very small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Ferrous oxide	faint traces.
Carbonic acid	somewhat large quantity.
Silica	traces.
Organic matter	traces.

Natural waters, *cont.*

Boiling produced a slight precipitate, consisting of carbonate of lime with a little carbonate of magnesia.

Water from a spring near Grande Prairie, B.C.

21.—From the same locality as the two preceding waters.

This, in so far as colour, taste, odour, and reaction, are concerned, closely resembled the preceding water. Its specific gravity, at 15·5° C., was found to be 1000·30, and it contained 0·336 parts of dissolved saline matter, dried at 180° C., in 1000 parts, by weight, of the water, or 23·5 grains per imperial gallon.

It was found to contain:

Potassa	faint traces.
Soda	very small quantity.
Lime	small quantity.
Magnesia	very small quantity.
Carbonic acid	somewhat large quantity.
Silica	traces.
Organic matter	traces.

Boiling produced a slight precipitate, consisting, as in the previous instance, of carbonate of lime with a little carbonate of magnesia.

MISCELLANEOUS EXAMINATIONS.

Anthraxolite.

1.—Anthraxolite. From a quartz vein traversing limestones and bituminous shales of the Cambrian system, at Lake Petitsikapau, Hamilton River, Ungava district, Labrador Peninsula. Collected by Mr. A. P. Low.

Structure, irregular, with intermixed fragments and numerous small particles of white translucent quartz, and thin films of ferric hydrate coating the walls of delicate fissures.

A proximate analysis gave:

Water at 110°-115° C	3·56
Additional loss on ignition in closed vessel	2·48
Fixed carbon	86·83
Ash	7·13
	100·00

The ash, which was of a light reddish-brown colour, was found by Mr. Wait to consist, for the most part, of silica. It would appear to be almost solely derived from accidental impurities, a view strengthened by the fact that other fragments of this material—which although most carefully picked, were not regarded as absolutely above suspicion—left on ignition but 0·31 per cent ash.

2.—Chromic iron ore. From the Coleraine Mining Company's area, about three-quarters of a mile south-east of the saw-mill, township of Coleraine, Megantic county, province of Quebec. Miscellaneous examinations, *cont.* Chromic iron ore.

A massive chromite, with which was associated small quantities of a light-greenish coloured serpentine. Mr. Johnston found it to contain :

Chromic oxide .... 52·82 per cent.

3.—Clay. From a deposit occurring at L'Orignal, township of Longueuil, Prescott county, province of Ontario. Clay.

Colour, bluish-gray, is non-calcareous, highly plastic, when burnt assumes a reddish-brown colour, is readily fusible at a somewhat elevated temperature. Is well suited for the manufacture of ordinary building brick.

4.—Cupriferous schist. From Copper Island, Shuswap Lake, Yale district, province of British Columbia. Cupriferous schist.

A schistose rock, stained and coated with hydrated peroxide of iron and green carbonate of copper, carrying small quantities of copper-pyrites. Mr. Wait found it to contain :

Copper.................................... 0·68 per cent.

5.—Graphitic rock. A massive, earthy, graphitic material, found about three-quarters of a mile from the chapel on River Dennis road, Inverness county, province of Nova Scotia—has been examined by Mr. Johnston, and found to contain : Graphitic rock.

Graphitic carbon........................... 32·80 per cent.

6.—Iron sand. A black ferruginous sand from Cape Commerell, Vancouver Island, province of British Columbia, has been specially examined, by Mr. Wait, for gold and platinum, and with negative results. Iron sand.

7.—Phosphatic shale. A specimen of a dark brownish-black Naiadites shale, from Dunvegan, Inverness county, province of Nova Scotia, has been examined by Mr. Wait, and found to contain 0·41 per cent of phosphoric acid, which corresponds to 0·895 per cent tribasic phosphate of lime. Phosphatic shale.

8.—Quartz-andesite (dacite). From Haddington Island, Broughton Strait, province of British Columbia. Collected by Dr. G. M. Dawson. Quartz-andesite.

Miscellaneous examinations, *cont.*

Mr. Wait has made a partial analysis of this rock, and found it to contain—Silica 70·5, alumina with a little iron 18·7, lime 2·7, magnesia, a very small quantity—undetermined ; alkalies, undetermined ; loss on ignition 0·8.

Sandstone.

9.—Sandstone. A specimen of Laramie sandstone from about thirty or forty miles above Edmonton, North Saskatchewan River, district of Alberta, North-west Territory. Collected by Dr. A. R. C. Selwyn.

A partial analysis of this, by Mr. Wait, gave—Siliceous matter 46·7, carbonate of lime 42·1, ferric oxide 5·5, magnesia, a small quantity, and other constituents, undetermined.

GEOLOGICAL SURVEY OF CANADA

G. M. DAWSON, C.M.G., LL.D., F.R.S., Director

DIVISION OF

MINERAL STATISTICS AND MINES

ANNUAL REPORT

FOR

1893 & 1894

ELFRIC DREW INGALL

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of Canada

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Assistant to the Division

OTTAWA

PRINTED BY S. E. DAWSON, PRINTER TO THE QUEEN'S MOST
EXCELLENT MAJESTY

1895

NOTES.

YEAR AND TON USED.

Except for the figures of imports, which refer to the fiscal year, ending 30th June in the current calendar year, the year used throughout this report is the calendar year. The ton is that of 2,000 pounds, unless otherwise stated.

EXPORTS AND IMPORTS.

The figures given throughout the report referring to exports and imports, are compiled from data obtained from the books of the Customs Department, and will occasionally show discrepancies, which, however, there are no means of correcting.

The exports and imports, under the heading of each province, do not necessarily represent the production and consumption of the province, *e.g.*, material produced in Ontario is often shipped from Montreal and entered there for export, so falling under the heading, Quebec.

N.E.S. = Not elsewhere specified.

VALUES ADOPTED.

The values of the metallic minerals produced, as per returns to this department, are calculated on the basis of their metallic contents at the average market price of the metal for the current year. Spot values have been adopted for the figures of production of the non-metallic minerals.

ASSAYS.

Except where it is specially mentioned that assays quoted have been made by the Geological Survey, these are given entirely on the authority of the person quoted as supplying the information.

To Dr. G. M. Dawson, C.M.G., F.R.S., &c.,
Director Geological Survey of Canada.

Sir,—I beg herewith to hand you the report of the division on mining and mineral production, &c., throughout the Dominion for the year 1893.

As in past years it will be found to present as complete a review of the mineral activities of the country and of their commercial results as it is possible to obtain with the means at command. These include the personal investigations of the officers of the division, supplemented by the issue of circulars asking the production direct from the operators themselves. Information selected from official provincial reports and various other sources is also incorporated, with a view to giving an outline of all the authentic information available.

The labour of collecting, comparing and collating these very varied materials, so as to ensure accurate results and obtain a completely uniform presentment of them, is very great, but it is hoped that the result will prove satisfactory.

As in the past, care is taken to avoid injury to private interests in the manner of publishing results, and all returns of production of individual mines are treated as confidential unless otherwise arranged with those interested. The confidence of the mining community thus gained, has resulted in an increasingly hearty response to our circulars, although to complete our data personal application is yet necessary in a small number of instances, and a yet more prompt response on the part of all applied to, will help still further towards an earlier publication of the material.

The preliminary summary of the mineral production for 1893, a revision of which will be found in the first pages of this report, was ready for press 5th April, 1894.

Apart from the preparation of the annual report, the other functions of the division have been performed as heretofore. Numerous inquiries have been received and answered respecting mining and the mineral resources of the country.

In view of criticisms of these statistics which have been made recently, and from time to time in the past, it may be well to take this opportunity to explain the working methods adopted, in order to prevent

the misunderstandings which underlie such criticisms and suggestions and to correct the impression thereby conveyed to the public that the reports are unreliable.

The figures given throughout the reports are based upon returns obtained direct from the various operators, and the totals have for some years been checked by comparison with railway exports and all other available sources of information. It can be therefore fairly claimed, that they are as accurate as it is possible to make such figures.

After investigation of the subject we have, however, found that in the nature of things export, and railway figures can only be taken as approximately correct in most instances. In the case of the export figures, entries are made as a rule by those having no technical knowledge of mineral substances, and in the case of the railways, but few of the shipments are actually weighed, so that car-load lots, for instance, may differ considerably from the theoretical load of the car.

It is desired to gratefully acknowledge the aid received from various sources. Thanks are due to those who, although too numerous to mention individually, have by answering our circulars or letters provided much valuable material for the report. Special mention must be made of the services rendered by my colleague, Mr. H. P. H. Brumell, assistant to the division, for his very important and efficient aid in every branch of the work.

Our acknowledgments are also due to the provincial mining departments of Nova Scotia, Quebec, Ontario and British Columbia and to the Dominion Customs Department for aid received.

I have the honour to be, sir,

Your obedient servant,

ELFRIC DREW INGALL.

27th April, 1895.

Postscript.—The figures for 1894 having become available since this report was transmitted to the printer, it has been deemed advisable to incorporate these with the report for 1893, thus making it a joint report for the two years in respect to the statistics of production, exports and imports. The general information regarding mineral discoveries and development during 1894, is, however, reserved for the next report, wherein it is proposed to give a summary of progress for 1894 and 1895.

20th August, 1895.

SUMMARY OF THE MINERAL PRODUCTION OF CANADA IN 1893 AND 1894.

Product.	1893. Quantity.	1893. Value.	1894. Quantity.	1894. Value.
Metallic.				
Copper (fine, in ore, etc.).. lbs.	8,109,856	$ 875,865	2,737,016	$ 735,017
Gold.................... oz.	54,410	976,603	58,058	1,042,055
Iron ore .... tons.	125,602	299,368	109,991	226,611
Lead (fine, in ore, etc.)..... lbs.	2,135,023	78,996	5,703,222	185,355
Nickel (fine, in ore, etc.).. "	3,982,982	2,071,151	4,907,430	1,870,958
Platinum................ oz.	......	1,800	....	950
Silver (fine, in ore, etc)... "	....	330,128	847,697	534,049
Zinc .... lbs.	11,763	470	....	....
Total metallic..............	....	$ 4,634,381	....	$ 4,594,995
Non-metallic.				
Arsenic (white).. ... . tons.	....	....	7	420
Asbestus............... "	6,331	310,156	7,630	420,825
Chromite........... "	....	....	1,000	20,000
Coal.................. "	3,837,565	8,423,759	3,867,742	8,499,141
Coke................... "	61,078	161,790	58,044	148,551
Felspar................ "	575	4,525	....	....
Fireclay and mfrs. of...... "	540	700	539	2,167
Grindstones.............. "	4,600	38,379	3,757	32,717
Gypsum................. "	192,568	196,150	223,631	202,031
Limestone for flux........ "	27,797	27,519	35,101	34,347
Lithographic stone.... ... "	....	....	180	30,000
Manganese ore .... "	213	14,578	74	4,180
Mica.................. lbs.	....	75,719	....	45,581
Mineral pigments—				
Baryta............. tons.	....	....	1,081	2,830
Ochres.............. "	1,070	17,710	611	8,690
Mineral water .... galls.	725,096	108,347	561,460	100,040
Moulding sand .... tons.	4,730	9,086	6,214	12,428
Natural gas...............	....	366,233	....	313,754
Petroleum............. brls.	798,406	834,334	829,104	835,322
Phosphate (apatite)....... tons.	8,198	70,942	7,290	43,740
Precious stones	....	1,500	....	1,500
Pyrites................. tons.	58,542	175,626	40,527	121,581
Quartz....................	100	500	....	....
Salt.................. tons.	62,324	195,926	57,199	170,687
Soapstone.............. "	717	1,920	916	1,640
Whiting .... brls.	....	....	500	750
Structural materials and clay products—				
Bricks .... M.	290,000	*a* 1,800,000	....	1,800,000
Building stone....... c. yds.	....	*a.* 1,100,000	....	1,200,000
Cement, natural..... brls.	126,673	130,167	} 108,142	144,637
do Portland ...... "	31,924	63,848		
Flagstones ....sq. ft.	40,500	3,487	152,700	5,298
Granite.............. tons.	22,521	94,393	16,392	109,936
Lime .... bush.	6,750,000	*a* 900,000	....	*a.* 900,000
Marble............. tons.	590	5,100	....	....
Pottery..................	....	213,186	....	162,144
Roofing cement......... tons.	951	5,441	815	3,978
Sands and gravels, exports "	329,116	121,795	324,656	86,940
Sewer pipe...............	....	350,000	....	250,325
Slate .... tons.	7,112	90,825	....	75,550
Terra cotta............ "	....	55,704	....	65,600
Tiles............... M.	100,000	*a* 200,000	....	200,000
Total non-metallic..........	....	$16,169,345	....	$16,057,330
do metallic..........	....	4,634,381	....	4,614,995
Estimated value of mineral products not returned (principally structural materials)...........	....	296,274	....	297,675
Total..................	....	$21,100,000	....	$20,950,000

(*a*) Estimated.

Exports.

Minerals and Mineral Products Mined or Manufactured in Canada during 1893.

Product.	Value.	Product.	Value.
Asbestus, first class	$ 41,084	Mineral pigments	$ 819
" second class	287,619	Nickel	629,692
" third class	10,004	Oil, crude	3,696
Bricks	44,110	" refined	394
Cement	1,172	Ore, iron	7,590
Clay, manufactures of	147	" manganese	12,521
Coal	3,270,384	Phosphate	67,952
Copper	269,160	Plumbago, crude	38
Felspar	500	" manufactures	10
Gold	268,939	Pyrites	68,527
Grindstones	21,672	Salt	1,267
Gypsum, crude	159,262	Sand and gravel	121,795
" ground	22,132	Silver	213,695
Iron and steel . . . about	300,000	Slate	3,168
Lead	3,099	Stone, unwrought	37,662
Lime	86,623	" wrought	9,102
Mica, crude	67,087	Other articles	11,543
" cut	2,057		
" ground	937	Total	$6,045,459

Exports

Of Products of the Mine, with Destinations, During the Fiscal Year 1892–1893.

Exported to	Value.	Exported to	Value.
United States	$4,756,280	China	$9,843
Great Britain	244,560	Danish West Indies	5,466
Newfoundland	166,221	Holland	4,750
Germany	37,400	Norway and Sweden	850
Hawaiian Islands	32,172	Belgium	414
British West Indies	25,733	British Guiana	195
Saint Pierre	19,872	U. S. of Colombia	32
Spanish West Indies	13,538		
Japan	12,564	Total	$5,329,890

IMPORTS.

MINERALS AND MINERAL PRODUCTS FOR FISCAL YEAR 1892-1893.

Product.	Value.	Product.	Value.
Alum and aluminous cake	$ 27,910	Lead and mfrs. of	281,590
Aluminum and alumina	1,700	Lime	4,917
Antimony	14,771	Litharge	24,401
Arsenic	12,907	Lithographic stone	4,449
Asbestus and mfrs. of	19,181	Manganese, oxide of	3,696
Asphaltum	36,208	Marble	96,177
Borax	31,069	Mercury	22,998
Brass and mfrs. of	499,144	Mineral water	57,953
Bricks	14,108	Nickel	15
" bath	1,921	Ochres	23,134
" and tiles, fire	125,900	Paraffine wax	40,670
Buhrstones	3,552	Petroleum and mfrs. of	472,406
Building stone	56,510	Plaster of Paris	3,143
Cement	10,969	Platinum	14,082
" Portland	316,179	Potash salts	48,864
Chalk	9,966	Precious stones	115,086
Clay, China	27,981	Pumice	3,998
" fire	42,587	Salt	361,300
" all other, N.E.S.	10,865	Sand and gravel	31,739
Coal, anthracite	6,355,285	Silex	1,301
" bituminous	3,967,764	Slate	51,179
" dust, &c	44,474	Soda salts	451,621
" tar and pitch	21,932	Stone and granite, N.E.S.	49,323
Coke	157,942	Spelter	49,822
Copper and mfrs. of	475,046	Sulphate of copper	40,747
Copperas	2,410	Sulphur	77,216
Earthenware	709,737	Sulphuric acid	2,367
Emery	23,368	Tiles, sewer pipes, &c	39,001
Fertilizers	21,580	Tin and mfrs. of	1,242,994
Flagstones	8,500	Whiting	25,563
Fuller's earth	3,113	Yellow metal	61,851
Graphite and mfrs. of	42,939	Zinc and mfrs. of	131,824
Grindstones	20,987		
Gypsum	1,456	Total	$25,377,185
Iron and steel	8,421,957		

ABRASIVE MATERIALS.

ABRASIVE MATERIALS

PRODUCTION.

The only material coming under this head for which there is any production to report is that of grindstones.

Grindstones.—The production for the year 1893 is shown below. On comparison with 1892 there is seen to be a falling off of 683 tons or nearly thirteen per cent. Grindstone

Nova Scotia	2,112 tons,	valued at	$21,000
New Brunswick	2,488 "	"	17,379
	4,600 "	"	$38,379

ABRASIVE MATERIALS.

Grindstones.

According to the statements of operators, the industry, which finds its market largely in the United States, felt the results of the commercial depression there prevailing.

The production for past years was as follows :—

1886—4,000 tons, valued at		$46,545
1887—5,292	" "	64,008
1888—5,764	" "	51,129
1889—3,404	" "	30,863
1890—4,884	" "	42,340
1891—4,479	" "	42,587
1892—5,283	" "	51,187
1893—4,600	" "	38,379

The production for 1894 was as follows :—

Nova Scotia	2,128	tons valued at	$16,000
New Brunswick	1,629	" " "	16,717
	3,757	" " "	$32,717

Infusorial earth.

Infusorial Earth.—Two additional deposits of this material have been met with in the course of the work of the Geological Survey in 1893. One is in the concession of Trompe Souris, of the parish of St. Justin, in Maskinongé county, Quebec, where it occurs in small quantity at a few feet below the surface in a sand bank sixty to seventy feet high. The other deposit is on lot 15, range V., of Chertsey, in Montcalm county, Quebec, about twelve miles from the town of Rawdon in that county, and is found at the bottom of a marshy bay of Lac Michel, covering an area of three or four acres with a thickness of about eighteen inches.*

* Summary Report of the Geological Survey for 1893, pp. 35.

Exports and Imports.

Abrasive Materials.

Exports and imports.

The following tables give the exports and imports of various abrasive materials, compiled from data furnished by the Customs Department.

Abrasive Materials.

Table 1.

Exports of Grindstones.

Year.	Value.
1884	$28,186
1885	22,606
1886	24,185
1887	28,769
1888	28,176
1889	29,982
1890	18,564
1891	28,433
1892	23,567
1893	21,672
1894	12,579

Abrasive Materials.

Table 2.

Exports of Grindstones.

Provinces.	1891.	1892.	1893.	1894.
Quebec	....	....	$ 625	$ 1
Nova Scotia	$ 12,387	$ 10,575	11,317	10,048
New Brunswick	16,046	12,992	9,730	2,530
Totals	$ 28,433	$ 23,567	$ 21,672	$ 12,579

ABRASIVE MATERIALS.

Exports and imports.

ABRASIVE MATERIALS.

TABLE 3.

IMPORTS OF GRINDSTONES.

Fiscal Year.	Tons.	Value.
1880	1,044	$11,714
1881	1,359	16,895
1882	2,098	30,654
1883	2,108	31,456
1884	2,074	30,471
1885	1,148	16,065
1886	964	12,803
1887	1,309	14,815
1888	1,721	18,263
1889	2,116	25,564
1890	1,567	20,569
1891	1,381	16,991
1892	1,484	19,761
1893	1,682	20,987
1894	1,918	24,426

ABRASIVE MATERIALS.

TABLE 4.

IMPORTS OF BUHRSTONES.

Fiscal Year.	Value.
1880	$12,049
1881	6,337
1882	15,143
1883	13,242
1884	5,365
1885	4,517
1886	4,062
1887	3,545
1888	4,753
1889	5,465
1890	2,506
1891	2,089
1892	1,464
1893	3,552
1894	3,029

ABRASIVE MATERIALS.

Exports and imports.

Abrasive Materials.

Table 5.

Imports of "Silex."

Fiscal Year.	Cwt.	Value.
1880	5,252	$2,290
1881	3,251	1,659
1882	3,283	1,678
1883	3,543	2,058
1884	3,259	1,709
1885	3,527	1,443
1886	2,520	1,313
1887	14,533	5,073
1888	4,808	2,385
1889	5,130	1,211
1890	1,768	2,617
1891	3,674	1,929
1892	1,429	1,244
1893	2,447	1,301
1894	2,451	1,521

Abrasive Materials.

Table 6.

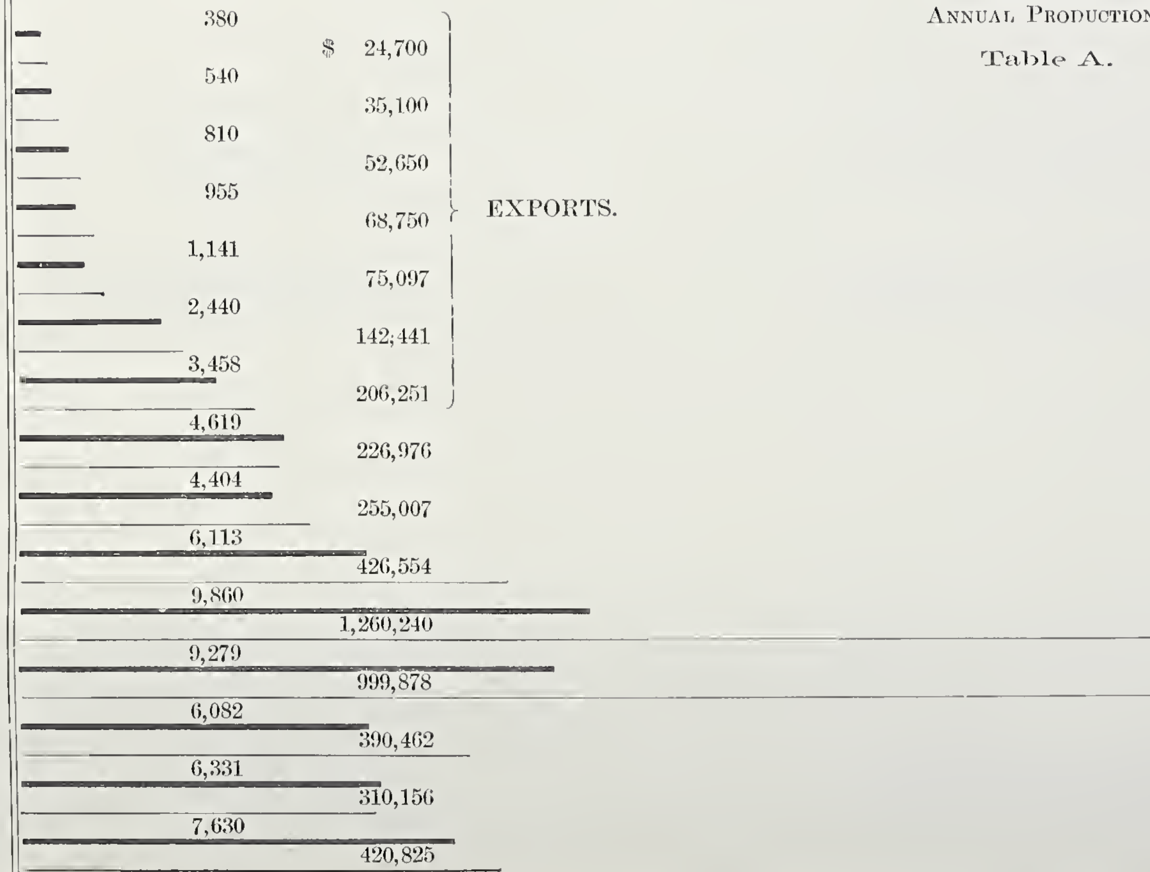
Imports of Pumice Stone and Emery.

Fiscal Year.	Pumice Stone.	Emery.
1885	$ 9,384	$ 5,066
1886	2,777	11,877
1887	3.594	12,023
1888	2,890	15,674
1889	3,232	13,565
1890	3,003	16,922
1891	3,696	16,179
1892	3,282	17,782
1893	3,798	17,762
1894	4,160	14,433

ASBESTUS.

ANNUAL PRODUCTION.

Table A.



Year.	Tons.	Value.	
1880	380	$ 24,700	EXPORTS.
1881	540	35,100	EXPORTS.
1882	810	52,650	EXPORTS.
1883	955	68,750	EXPORTS.
1884	1,141	75,097	EXPORTS.
1885	2,440	142,441	EXPORTS.
1886	3,458	206,251	EXPORTS.
1887	4,619	226,976	
1888	4,404	255,007	
1889	6,113	426,554	
1890	9,860	1,260,240	
1891	9,279	999,878	
1892	6,082	390,462	
1893	6,331	310,156	
1894	7,630	420,825	

ASBESTUS.

Asbestus.

Production.

The production of asbestus during 1893 was, according to direct returns to this office, 6,331 tons valued at $310,156 which as compared with last year's figures shows an increase of 249 tons in the production, but a decrease of $80,306 in the total value.

The fluctuations in production for past years are well shown in graphic table A, wherein will be found also the figures of production for 1894, which shows a very encouraging increase of business done.

Exports and Imports.

Exports and imports.

The following tables, Nos. 1 and 2, are self-explanatory :—

Asbestus.

Table 1.

Exports.

Quality.	1891.		1892.		1893.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1st class	4,530	$338,072	1,447	$113,595	975	$ 41,084	5,400	$312,280
2nd "	3,186	209,833	3,185	228,133	4,592	287,619	1,322	106,374
3rd "	298	13,636	748	31,375	350	10,004	1,265	5,9183
Totals.....	8,014	$561,541	5,380	$373,103	5,917	$338,707	7,987	$477,837

Asbestus.

Table 2.

Imports.

Fiscal Year.	Value.
1885......................	$ 674
1886......................	6,831
1887......................	7,836
1888......................	8,793
1889......................	9,943
1890......................	13,250
1891......................	13,298
1892......................	14,090
1893......................	19,181
1894......................	20,021

Discovery and Development.

Quebec.

Asbestus.

Discovery and development.

There is little or nothing new to report in connection with the asbestus industry for the year 1893. As shown by the figures of production, the demand and prices have continued to fall off very considerably for the past three years. This lessened production has in no way been due to the working out of the districts, but must be credited to the exterior economic conditions.

All but a small proportion of the total production given, is from the Black Lake and Thetford districts, the only mine operated to any extent outside of these being that near Danville. Thus all the output of this mineral must be credited to the Eastern Townships, with the exception of a small shipment made from the Templeton Mine in Ottawa county. No mining work, however, was done at this place, the shipment being made from the material already on the dumps.

There were received thirteen returns giving production, and fifteen which stated that no work had been done during the year.

Ontario.

The only work to report as done outside of Quebec, is that of the Standard Asbestus Company of New York, on lots 7 and 8, concession 11, Elzevir township, in the county of Hastings, under the superintendance of Mr. James E. Harrison, who furnishes the following notes :—" Worked five and a half months sinking test shaft on magnesian range in vein of serpentine and chrysotile. Shaft over fifty feet deep. Took out about 400 tons, averaging over 50 per cent fibre. Shipped 100 tons (2,000 lbs.) to company's mill in Elizabeth, N.J., also 15 tons to Gouverneur, N.Y., all for tests." There were four men employed on this work. The material mined at this place is mostly used in the manufacture of roofing cements, and is different from that produced in Quebec, being mineralogically classed as actinolite.

As the mode of occurrence of the asbestus deposits of Canada, together with details of the method of working them, has been fully given in former reports, there will be no need to here restate the facts.

CHROMITE.

Chromite.

The existence of deposits of this mineral in Canada has been long known, mention of several occurrences being made in the volume issued by the Geological Survey in 1863, entitled the " Geology of Canada."

The deposits now receiving attention are all situated in the Eastern Townships of Quebec, where they are found in the serpentine rocks of that region. Bodies of this serpentine rock are frequent, and often of considerable extent, their position and distribution being well shown on the geological maps issued by the Survey. Mention is made of these deposits also in reports of the Survey. CHROMITE.

The mineral occurs in irregular pockets of very varying extent. They have received attention from time to time, but until the present, the work done has been irregular and small in amount. In April of 1894, a new discovery of the mineral on the lands of the Coleraine Mining Co. near Black Lake Station on the Quebec Central railway, again revived interest in this mineral, and the consequent renewal of prospecting has led to further discoveries.

The analyses given in the "Geology of Canada" show a content of about 60 per cent of chromic acid, but these were probably selected specimens, and the shipping grade will most likely only run about 50 to 52 per cent of the sesquioxide (Cr_2O_3) or even lower.

For use in the manufacture of bichromate of potash, the makers demanded an ore carrying 50 per cent of the sesquioxide.

So far as can be ascertained, the production of this mineral for 1894 was about 1,000 tons, which at $20 per ton would give a total spot value at shipping point of $20,000. The data to hand are somewhat contradictory, as by direct returns to this office some 2,234 tons were produced. This is evidently in error and must represent ore merely mined besides that shipped, which from other sources is learned to be as above.

In the reports of this division for 1886 and 1887, the following figures of production are given :—

1886—60 tons with a spot value of........	$945
1887—38 " " "	570

The market price per ton of ore seems to have been pretty low in these years or it must have been low grade, as in 1863 the price quoted for 50 per cent was about $55 per ton. In 1894 the price quoted is $26 per ton for the same grade delivered at the works, or about $20 per ton delivered on the cars at the nearest shipping point to the mine.

COAL.

COAL.

STATISTICS.

Statistics.

The total amount of coal mined during 1893 was 3,837,565, tons valued at $8,423,759, showing an increase over the previous year of 545,018 tons in quantity and in value of $1,239,249, or $16\frac{1}{2}$ and $17\frac{1}{4}$ per cent respectively. This increase is not attributable to any

Coal.

Production.

province in particular, but is largely due to the increased output of the two great producing provinces, Nova Scotia and British Columbia. The yearly production is shown for this and past years in graphic table A, to which has been added that for 1894 :—

COAL.
Annual Production.
Table A.

Year.	Tons.	Value. $
1886	2,091,976	4,017,225
1887	2,418,494	4,758,590
1888	2,658,134	5,259,832
1889	2,719,478	5,584,182
1890	3,117,661	6,496,110
1891	3,623,076	8,144,247
1892	3,292,547	7,184,510
1893	3,837,565	8,423,759
1894	3,867,742	8,499,141

In graphic table B, is shown the production by provinces, and it will there be seen that Nova Scotia continues to be the largest producer, though by reason of the higher price ruling on the Pacific

Coast the value of the production of British Columbia is slightly in excess. COAL. Production.

COAL
1893
PRODUCTION BY PROVINCES
Table B

Province.	Tons.	Value.
N. S.	2,497,281	$3,902,001
B. C.	1,095,689	3,913,176
N. W. T.	238,395	598,745
N. B.	6,200	9,837

COAL
1894
PRODUCTION BY PROVINCES
Table B

Province.	Tons.	Value.
		$
N. S.	2,526,775	3,948,085
B. C.	1,134,507	4,051,812
N. W. T.	199,981	488,980
N. B.	6,469	10,264

COAL.
Production.

The production in the provinces of Nova Scotia and British Columbia during the past years is shown in the following graphic tables C and D.

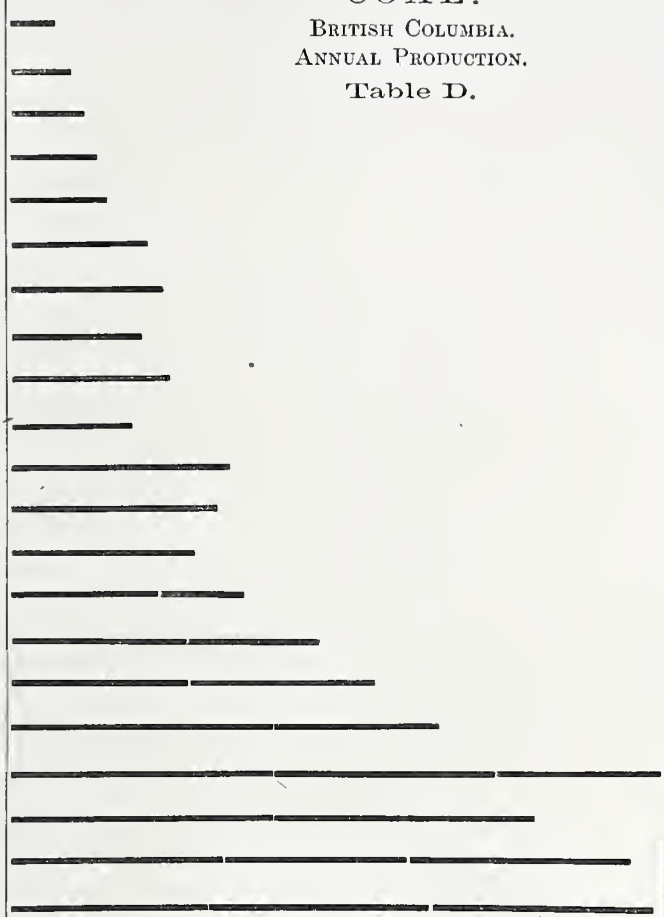
COAL
NOVA SCOTIA
ANNUAL PRODUCTION
Table C

Year.	Tons.
1870	700,860
1871	754,031
1872	984,664
1873	1,117,643
1874	977,446
1875	848,395
1876	794,803
1877	848,395
1878	863,081
1879	882,863
1880	1,156,635
1881	1,259,182
1882	1,529,708
1883	1,593,259
1884	1,556,010
1885	1,514,470
1886	1.682,924
1887	1,871,338
1888	1,989,263
1889	1,967,032
1890	2,222,081
1891	2,290,935
1892	2,175,914
1893	2,497,281
1894	2,526,775

COAL.
Production.

COAL.
BRITISH COLUMBIA.
ANNUAL PRODUCTION.
Table D.

Year.	Tons.
1874	81,574
1875	110,145
1876	131,192
1877	154,052
1878	170,846
1879	241,301
1880	267,595
1881	228,357
1882	282,139
1883	213,299
1884	394,070
1885	365,596
1886	326,636
1887	413,360
1888	548,017
1889	649,409
1890	759,517
1891	1,152,588
1892	925,495
1893	1,095,689
1894	1,134,507



The production in the province of New Brunswick and the North-west Territories during past years is shown in the following table :—

COAL.
TABLE 1.
PRODUCTION IN NEW BRUNSWICK AND NORTH-WEST TERRITORIES.

Year.	New Brunswick.		North-west. Territories	
	Tons.	Value.	Tons.	Value.
1887.............	10,040	$ 23,607	74,152	$ 157,577
1888.............	5,730	11,050	115,124	183,354
1889.............	5,673	11,133	97,364	179,640
1890.............	7,110	13,850	128,953	198,498
1891.............	5,422	11,030	174,131	437,243
1892.............	6,768	9,375	184,370	469,930
1893.............	6,200	9,837	238,395	598,745
1894.............	6,469	10,264	199,991	488,980

Exports and Imports.

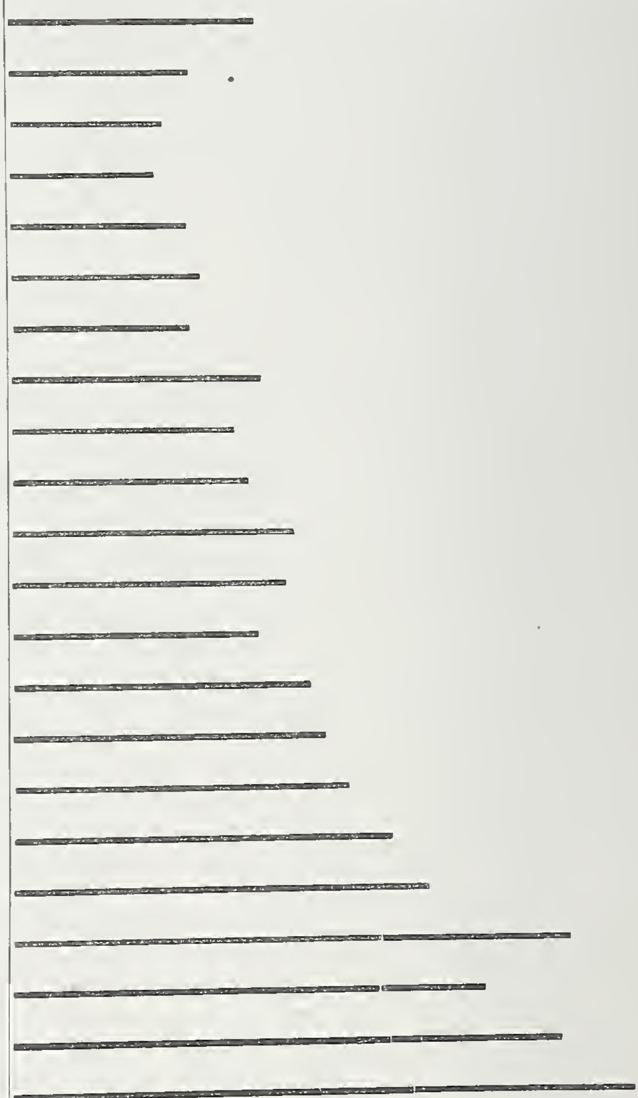
Coal.

Exports and imports.

As in past years the figures of exports and imports of coal are taken from returns received from the Customs Department. In the following graphic tables, E and F, are shown the exports of the Dominion, both of domestic and foreign coal.

COAL
EXPORTS.
(PRODUCE OF CANADA)
Table E.

Year.	Tons.
1873	420,683
1874	310,988
1875	250,348
1876	248,638
1877	301,317
1878	327,959
1879	306,648
1880	432,188
1881	395,382
1882	412,682
1883	486,811
1884	474,405
1885	427,937
1886	520,703
1887	580,965
1888	588,627
1889	665,315
1890	724,486
1891	971,259
1892	823,733
1893	960,312
1894	1,103,694

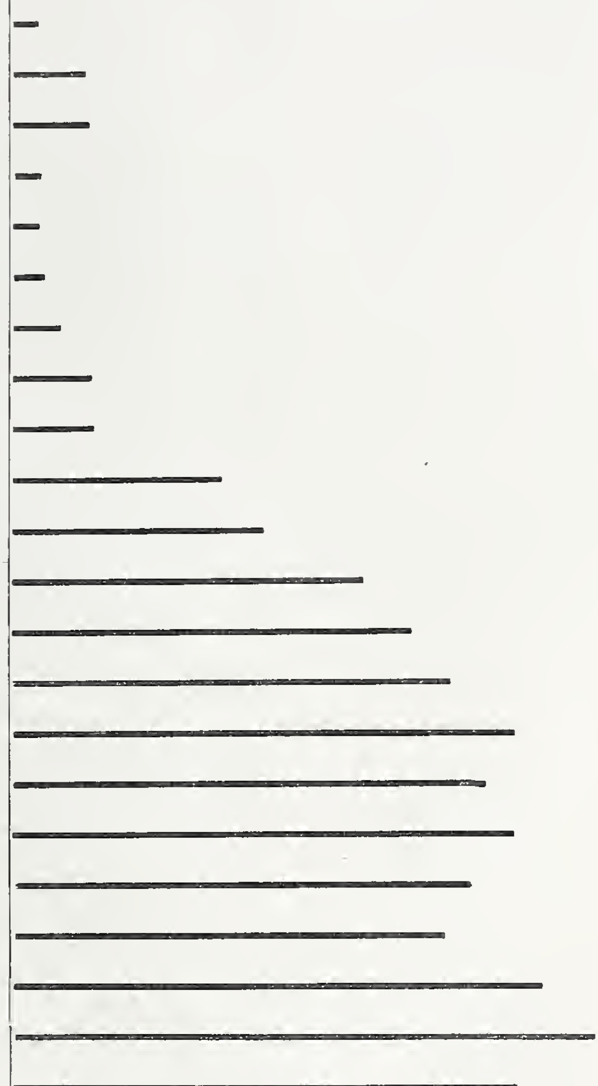


COAL.

Exports and imports.

COAL
EXPORTS.
(NOT THE PRODUCE OF CANADA)
Table F.

Year.	Tons.
1873	5,403
1874	12,859
1875	14,026
1876	4,995
1877	4,829
1878	5,468
1879	8,468
1880	14,217
1881	14,245
1882	37,576
1883	44,388
1884	62,665
1885	71,003
1886	78,443
1887	89,098
1888	84,316
1889	89,294
1890	82,534
1891	77,827
1892	93,988
1893	102,827
1894	89,786



COAL.

Exports and imports.

COAL.

TABLE 2.

EXPORTS: THE PRODUCE OF CANADA.

Provinces.	1893.		1894.	
	Tons.	Value.	Tons.	Value.
Ontario	....	$ 2	104	$ 115
Quebec	712	1,118	7,600	22,995
Nova Scotia	203,198	470,695	310,277	633,398
New Brunswick	6,699	21,260	919	2,948
Prince Edward Island	....	....	1,221	2,850
Manitoba	....	2	.....	.....
North-west Territories	41,475	83,560	13,134	24,293
British Columbia	708,228	2,693,747	770,439	2,855,216
Total	960,312	3,270,384	1,103,694	3,541,815

COAL.

TABLE 3.

EXPORTS: NOT THE PRODUCE OF CANADA.

Provinces.	1893.		1894.	
	Tons.	Value.	Tons.	Value.
Ontario	39,205	$ 240,461	83,599	$ 184,314
Quebec	1,230	1,603	5,338	11,378
Nova Scotia	2,105	4,790	631	1,374
New Brunswick	287	1,032	218	577
Manitoba	.....	....	.....	.....
British Columbia	....	....	.....	.....
Total	102,827	247,886	89,786	197,643

The following, table 4, illustrates the exports of coal from the two large producing provinces, Nova Scotia and British Columbia, and shows in the case of both provinces a large increase in business done in 1893 and 1894 over the preceding years.

COAL.

Exports and imports.

COAL.

TABLE 4.

EXPORTS: NOVA SCOTIA AND BRITISH COLUMBIA.

Year.	Nova Scotia.		British Columbia.	
	Tons.	Value.	Tons.	Value.
1874	252,124	$647,539	51,001	$ 278,180
1875	179,626	404,351	65,842	356,018
1876	126,520	263,543	116,910	627,754
1877	173,389	352,453	118,252	590,263
1878	154,114	293,795	165,734	698,870
1879	113,742	203,407	186,094	608,845
1880	199,552	344,148	219,878	775,008
1881	193,081	311,721	187,791	622,965
1882	216,954	390,121	179,552	628,437
1883	192,795	336,088	271,214	946,271
1884	222.709	430,330	245,478	901,440
1885	176,287	349,650	250,191	1,000,764
1886	240,459	441,693	274,466	960,649
1887	207,941	390,738	356,657	1,262,552
1888	165,863	330,115	405,071	1,605,650
1889	186,608	396,830	470,683	1,918,263
1890	202,387	426,070	508,882	1,977,191
1891	194,867	417,816	767,734	2,958,695
1892	181,547	407,980	599,716	2,317,734
1893	203,198	470,695	708,228	2,693,747
1894	310,277	633,398	770,439	2,855,216

The three following tables, 5, 6 and 7, are of imports, and are self-explanatory. Attention is again drawn to the fact that these are for the fiscal year ending 30th June, 1894:—

COAL.

TABLE 5.

IMPORTS OF BITUMINOUS COAL.

Fiscal Year.	Tons.	Value.
1880	457,049	$1,220,761
1881	587,024	1,741,568
1882	636,374	1,992,081
1883	911,629	2,996,198
1884	1,118,615	3,613,470
1885	1,011,875	3,197,539
1886	930,949	2,591,554
1887	1,149,792	3,126,225
1888	1,231,234	3,451,661
1889	1,248,540	3,255,171
1890	1,409,282	3,528,959
1891	1,598,855	4,060,896
1892	1,615,220	4,099,221
1893	1,603,154	3,967,764
1894	1,359,509	3,315,094

COAL.

Exports and imports.

COAL.

TABLE 6.

IMPORTS OF ANTHRACITE COAL.

Fiscal Year.	Tons.	Value.
1880	516,729	$1,509,960
1881	572,092	2,325,937
1882	638,273	2,666,356
1883	754,891	3,344,936
1884	868,000	3,831,283
1885	910,324	3,909,844
1886	995,425	4,028,050
1887	1,100,165	4,423,062
1888	2,138,627	5,291,875
1889	1,291,705	5,199,481
1890	1,201,335	4,595,727
1891	1,399,067	5,224,452
1892	1,479,106	5,640,346
1893	1,500,550	6,355,285
1894	1,530,522	6,354,040

COAL.

TABLE 7.

IMPORTS OF COAL DUST.

Fiscal Year.	Tons.	Value.
1880	3,565	$ 8,877
1881	337	666
1882	471	900
1883	8,154	10,082
1884	12,782	14,600
1885	20,185	20,412
1886	36,230	36,996
1887	31,401	33,178
1888	28,808	34,730
1889	39,980	47,139
1890	53,104	29,818
1891	60,127	36,130
1892	82,091	39,840
1893	109,585	44,474
1894	117,573	49,510

On reference to the foregoing tables, and assuming the fiscal year to be the same as the calendar, there will be seen to have been a market for coal of all kinds in Canada equivalent to 5,987,717 tons as follows :— COAL. Consumption.

	Tons.
Production	3,837,567
Imports	3,213,289
	7,050,856
Less exports	1,063,139
	5,987,717

From previous statistics there is found to have been a yearly market as follows :—

	Tons.
1886	3,593,266
1887	4,406,916
1888	4,646,513
1889	4,519,787
1890	4,974,362
1891	5,632,039
1892	5,552,243
1893	5,987,717
1894	5,681,866

MARKETS.

The market for the bulk of the coal exported from Canada is still the United States, though of the Nova Scotia coal Newfoundland takes the greater quantity of that exported. Markets.

Of British Columbia coal, however, the United States, at the port of San Francisco alone, took 549,560 tons, while it is estimated that the lower ports in California took 200,000 tons more. Small shipments were also made to Alaska, Hawaii and to Eastern Siberia and other Asiatic countries.

NOVA SCOTIA.

COAL.
Nova Scotia.

The figures contained in the following tables are taken from information received from the Department of Mines of Nova Scotia and represent the production, etc., of that province :—

COAL.

TABLE 8.

NOVA SCOTIA.

PRODUCTION, SALES AND COLLIERY CONSUMPTION.

Period.	Production.	Sales.	Colliery consumption.
	Tons.	Tons.	Tons.
1893, 1st quarter	454,465	275,468	50,830
1893, 2nd "	650,122	588,973	47,977
1893, 3rd "	780,051	799,794	61,456
1893, 4th "	612,643	535,209	53,486
Totals	2,497,281	2,199,444	213,749
1892	2,175,914	1,963,286	196,103
1891	2,290,935	2,071,938	195,981
1890	2,222,081	2,000,444	180,589
1889	1,967,032	1,741,720	177,106
1888	1,989,263	1,765,895	176,336
1887	1,871,338	1,702,046	156,550
1886	1,682,924	1,538,504	159,512
1885	1,514,470	1,405,051	142,939

COAL.

TABLE 8a.

NOVA SCOTIA.

PRODUCTION, SALES AND COLLIERY CONSUMPTION.

Period.	Production.	Sales.	Colliery Consumption.
1894, 1st quarter........ Tons.	364,396	250,912	56,651
1894, 2nd " ..... "	675,179	610,091	45,441
1894, 3rd " ..... "	819,520	850,494	50,472
1894, 4th " ..... "	642,311	579,054	56,964
Total .... "	2,501,406	2,290,551	209,528

Coal.

Nova Scotia.

Coal.

Table 8b.

Nova Scotia.

Production by Collieries for 1884.

Colliery.	Tons.	Colliery.	Tons.
Chignecto	587	Gowrie	154,880
Joggins	114,943	International.....	154,550
Minudie.........	2,671	Reserve	249,848
Springhill	485,997	Victoria....	146,646
Maccan	....	Sydney.........	287,629
Acadia...........	256,038	Scotia	925
East River.......	....	Dominion No. 1..	41,891
Intercolonial......	249,406	Broad Cove.. ...	324
Old Bridgeport....	59,211	Mabou	108
Caledonia	144,806	Cape Breton	14,682
Gardener.........	....		
Glace Bay........	160,804	Total.........	2,525,946

Coal.

Table 9.

Nova Scotia.

Coal Trade by Counties.

1893.	Cumberland.		Pictou.		Cape Breton.		Other counties.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Rais-ed.	Sold.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1st quarter..	164,101	149,247	121,281	96,223	169,083	29,998	.... .	......
2nd "	145,488	130,934	150,969	136,967	353,138	320,604	527	468
3rd "	142,311	115,628	147,800	146,673	489,778	537,291	162	202
4th "	164,064	136,156	136,502	127,348	312,077	271,705	....	.....
Totals....	615,964	531,965	556,552	507,211	1,324,076	1,159,598	689	670
" 1892.	513,512	473,365	503,692	454,112	1,156,808	1,034,733	1,902	1,076
" 1891.	583,688	517,739	500,829	453,707	1,206,064	1,100,279	354	213

Coal.

Nova Scotia.

Coal.

Table 9a.

Nova Scotia.

Coal Trade by Counties.

Year 1894.	Cumberland.		Pictou.		Cape Breton.		Other Counties.	
	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.	Raised.	Sold.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
First quarter	154,645	139,418	102,009	84,314	107,472	26,955	270	226
Second "	148,957	136,549	132,594	118,320	188,031	350,356	5,599	4,865
Third "	141,030	124,480	139,607	131,501	531,309	587,361	7,573	7,152
Fourth "	160,399	137,158	133,474	119,773	348,298	322,022	139	101
Totals, 1894.	605,031	537,605	507,684	453,908	1,324,076	1,286,694	13,581	12,344
" 1893.	615,964	531,965	556,553	507,211	1,375,011	1,159,598	689	670

Coal.

Table 10.

Nova Scotia.

Distribution of Coal Sold.

Market.	1892.	1893.	1894.
	Tons.	Tons.	Tons.
Nova Scotia, transported by land	391,023	453,611	418,123
" " " sea	307,832	316,883	338,121
Total, Nova Scotia	698,855	779,494	756,244
New Brunswick	240,296	285,669	261,262
Prince Edward Island	63,435	66,961	70,532
Quebec	835,561	959,139	973,617
Newfoundland	106,399	87,347	114,204
West Indies	3,191	1,689	10,743
United States	15,549	28,108	114,686
Other countries	....	37	2,005
Total	1,963 286	2,199,444	2,303,293

Owing to the change recently made by the province in the period covered by the fiscal year, which now ends 30th September, many of the comparisons made in previous reports have to be omitted.

DISCOVERY AND DEVELOPMENT.

COAL.

Discovery and development in Nova Scotia

The following notes regarding operations in Nova Scotia are taken from the report of the Department of Mines of that province. They tend to show that the mining was carried on as in past years, little work being done elsewhere than at the old established collieries.

Pictou County.

Intercolonial Coal Mining Company—The old slopes.—All the coal raised during the year was drawn from the 3,000 feet lift. On the north side, the levels were run to the line and the work of drawing the pillars is now being actively carried on, while to the south the levels were driven 2,600 feet where also the pillars are being drawn. The hauling plant has been removed to the 3,600 feet lift, to which the coal is lowered and drawn by tail-rope to the landing. The plant for handling the coal has been greatly improved and it is now found possible to do with three employees the work formerly performed by ten. A new screen was erected during the year, and a considerable amount of timbering and repairing was done in No. 4 slope, with the intention of reopening it if required. During the year the water supply ran very low, and, to guard against a recurrence of the danger, pipes have been laid a distance of two miles to the Stellarton reservoir.

Scott Pit.—Very little work was done in this pit during the year, operations being confined to sinking on the slants referred to in last year's report. This was continued until the advent of warm weather when, through the amount of gas given off, it was deemed advisable to discontinue operations and put the mine in good order. Work was then begun on the old slopes and a new fan capable of supplying 1,800 feet of air to the sinking force at 2,600 feet was substituted for the old furnace used to ventilate the pit. This supply was not, however, deemed sufficient to thoroughly dilute the escaping gas and all work was stopped, though it is intended to open up again in the fall of the year. A rather serious accident occurred at the pit on the 8th of August. During a heavy thunder storm lightning descended the shaft by the steel wire cage ropes and caused an explosion of gas, but as the works were idle no loss of life occurred.

Albion Mines—Third seam.—Very little, if any, work was done on this seam on the south side of the slope, while to the north, No. 1 balance was completed, making a new double balance with nine bords on each side. No. 3 balance was nearly completed. The work of sinking a new lift was begun and operations on the Cage pit seam were carried

COAL.

Discovery and development in Nova Scotia

on and levels advanced. On the south side the pillars were being successfully drawn. Separated from this seam by five or six feet and overlying it is a four-foot seam which is being successfully worked on the "long-wall" system. During the year the drifts leading from the Ford pit seam were built off with brick and stone.

The bank house has been remodelled and new screens of belt pattern were erected.

Acadia Mine.—This mine is now worked altogether on the long-wall system, and although working six to seven feet of coal, the work is being very successfully done. The management began work at the 2,400 feet lift intending to reopen the old level as part of new return airway; this level may in the future be utilized to draw the coal from the old Black Diamond mine.

Thorburn Mine—Six feet seam.—Work was actively carried on at this mine and the balance driven up to the 1,100 feet lift, from this ten bords were being worked, another balance was driven inside this and bords turned off. On the east side of the 1,800 feet lift most of the coal, except the pillars, has been won. On the new lift about fifteen places are being worked. The company were also engaged in proving a new seam known as the four-foot seam.

McGregor Pit.—"This mine has been worked continuously with a small force of men, and they are now prepared to draw the pillars in the No. 3 lift, east side, south slant; ventilation has been well kept up during the year."

Cage Pit.—"Some preparations were made to open the Cage Pit, but for various reasons this has not been done."

Ford Pit.—"This pit remains partially filled with water."

East River Mine.—"Messrs. Muir and Son worked this mine until March, when they stopped, leaving it in good condition."

Old Pottery Mine.—"Mr. Wm. P. McNeil, of New Glasgow, has re-opened this mine, pumped the water out, had it re-timbered, and is now taking out coal."

Cumberland County.

Spring Hill Mines, No. 1 Slope.—The greater part of the work done in this slope was performed on the 1,900 feet lift and the back seam, the coal on the west side of the old balances being mostly exhausted. The coal lift at the 200 feet barrier on the 1,300 feet lift was being successfully won and that between the 1,900 feet and Stoney levels was being taken out as the levels were advanced. Notwithstanding trouble

with fire damp the pillars and low coal of the large area in the back seam were successfully won. COAL.

In the back seam on the level going west a fault was struck which was pierced and the coal found again. Little work was done on the 2,600 feet lift beyond drawing the levels and places up to the 1,900 feet lift; the coal here is very tender, of good appearance and quality. Discovery and development in Nova Scotia

Spring Hill Mines, No. 2 Slope.—The drawing of pillars has been carried on here continuously since last year's report. In the new lift little has been done beyond extending the levels and other necessary work. These levels will need to be driven east about one mile to connect with the Aberdeen slope, and when this is accomplished they will have cut around a large block of coal 1,200 feet by about one mile. The intention of the management is to have the levels in this new lift extended and the work properly opened up before the coal is all drawn from the old lift above.

Spring Hill Mines, No. 3 Slope.—The level on the west side at the 1,300 feet lift has now been driven up connecting with the syndicate slope. A large block of coal on the east side of the 1,300 feet lift, extending up to the 800 feet lift has been thoroughly and successfully extracted. On the west side of the 1,900 feet lift the levels were driven 5,000 feet and No. 8 balance was driven up to the 1,300 feet lift. On the east side the levels are in some 1,300 feet.

Joggins Mine.—Work was carried on actively at this mine as in past years. On the surface the bank-house has been enlarged and belt screens erected.

Minudie Mine.—"This mine was re-opened, the water being all pumped out, but no coal was raised."

Chignecto Mine.—"Last year four or five men worked a few months during the winter along the outcrop."

Cape Breton County.

During the year "negotiations were concluded by which a company called the Dominion Coal Company (Limited) has acquired the properties known as the Gowrie, Ontario, Caledonia, Reserve, International, Glace Bay, Sword, and Gardner Collieries, embracing an area of about forty-nine square miles. This leaves the Sydney Mines and Victoria as the only independent collieries working in Cape Breton county. The collieries of the new company have been connected with Sydney Harbour by extensions of the International railway, and the railway is being extended to Louisbourg, with the intention of utilizing

COAL.

Discovery and development in Nova Scotia

the harbour as a winter port. The general manager of the new company is Mr. D. McKeen, M.P., well known for his successful management of the Caledonia Colliery.

"This extensive change of ownership naturally caused much interest to be taken in coal, and an immense number of licenses to search were applied for in this county. On a few some prospecting has been done. Mr. Stephens opened a bed containing about three feet six inches of good coal. The Messrs. Cossit proved a seam about four feet thick. On the Murray property, in the rear of Cow Bay, several large seams were reported as passed through by boring. The Messrs. Routledge did some boring to the west of the Lingan area, and are said to have found workable coal. On the North Sydney side of the harbour, a seam five or six feet thick was reported near the Little Bras d'Or, which should underlie and increase the value of the coal leases in that vicinity."

International Colliery.—Work was carried on at this mine as usual, the levels and rooms on the north and south sides of the deeps being extended and the rise workings on the south side pushed ahead. The bank and pit-head frame was destroyed by fire on the 30th of March. This, however, has been rebuilt.

Gowrie Mines.—Levels and rooms were extended as usual on the south side of the east deep from No. 1 and No. 2 landings. On the west side of this deep the levels on the low lift were driven about 600 feet and rooms turned off. From the bottom of the west deep slant a section of rooms were started due north up the dip which is about 17°.

The plant was improved by the addition of two tubular boilers 5 x 16 feet, with smoke stack, one 20 x 24 inch air compressor and ten Ingersoll coal cutting machines.

Caledonia Colliery.—Work at this colliery was carried on as usual. A new landing was made at the bottom of the east deep, levels driven on the south side and a large section opened up, while the east and west levels No. 4 were extended and rooms opened up. During the summer a circular fan shaft ten feet in diameter was sunk to a depth of 187 feet and was equipped with a twelve foot Murphy ventilator.

Little Glace Bay Colliery.—The dip levels were extended on the north and south sides of the deep slant, where about thirty rooms are being worked. The west high level was steadily advanced and a large section of rooms opened up; rooms were also opened on the west side of the main north level. The surface plant was increased by the addition of two 100 horse-power tubular boilers, one air compressor and ten Ingersoll coal cutting machines.

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Discovery and development in Nova Scotia

Reserve Colliery.—The levels on the east slope low lift were extended north and south and rooms opened. On the west slope the water was pumped out of the deep and about forty men put to work drawing pillars.

Emery Colliery.—"There is nothing new to note here. The deeps that were being driven have been stopped owing to a band of stone in the coal; the rooms on the east side to the rise of this have been extended. A dip slant has been driven on the west side of the pit-bottom down to the level, with the intention of hauling the west side deep coal up that way."

Old Bridgeport Colliery.—The south levels are now in 3,185 feet from the shaft, having been driven 1,630 feet since the change of ownership; they have now only about 150 feet to go before reaching the boundary line of the reserve.

The remainder of the places up the slant are all worked by hand as usual, the rooms being 18 feet wide and the pillars 100 ft. x 12 ft. A new furnace has been built this season, which has increased the ventilation. Two new Ingersoll tubular boilers have been erected on the surface, 14 feet long by 5 ft. in diameter, each having 84 tubes 3 inches in diameter, and built in on the improved method known as the Jarvis furnace.

It is the intention of the management this fall to enlarge the size of the shaft to admit of larger cages and tubs of greater capacity being used, so as to make the output of this pit next season something like 800 or 1,000 tons per day. A new engine house, which is to contain winding engine, an underground hauling engine, two compressors, and one emery stone, is to be built this fall, and also a new heapstead 55 feet high.

Gardner Mines.—An extension of the workings already opened up was made and a section of long-wall of about 300 feet in width worked in at the south level. The roof over the horse road was taken down for a distance of 500 feet giving more room for travel.

Victoria Mines.—The west slope low lift levels were extended 300 feet to the west, a balance driven up and 16 rooms won. The levels on the east side were extended about 650 feet and the levels on the 1,200 feet lift, east slope, driven eight feet, where balances and rooms were opened. A section of long-wall work was opened up during the year. The face is about 350 feet long and is driven up hill on the plane of the coal. The pillars in Nos. 5 and 6 balances were successfully drawn.

COAL.

Discovery and development in Nova Scotia

Sydney Mines.—On the south side of the pit in the new angle-deep levels and deeps were extended and a fine section of coal was opened up, while to the south in No. 2 angle the works were extended as usual. On the north side of the pit, the deep workings were extended in the different sections with good results.

Victoria County.

New Campbellton Mines.—This property was acquired by Messrs. Burchell Brothers who began operations in the spring, consisting in building a new wharf and reconstructing and relaying with steel rails the old railroad from the pit. Six blocks of miners' cottages were repaired and an engine house and blacksmith shop built.

The old slope was cleaned out and retimbered and a Cameron pump placed in the pit, with which it was expected to have the mine dry by October. Mr. Burchell states that the intention is to drive to the dip of the present workings and gain a new lift, as the coal seems to improve in quality towards the dip.

Inverness County.

"In the county of Inverness much interest was aroused in coal in the spring, and a large number of licenses applied for at Broad Cove, Chimney Corner and Port Hood. Little work has, however, been performed. Some borings are being made at Broad Cove, but up to date of writing the department is not advised as to their success. The Boston and Nova Scotia Coal Company have surveyed a route from Orangedale, on the Cape Breton railway, to Broad Cove, and have acquired some areas at that point. It is understood that they contemplate the immediate building of the road and a development of a coal mine at Broad Cove.

"At Mabou the Mabou Coal and Gypsum Company have continued working and developing during the season.

"At the Coal Mine Cove, two and a half miles east of Mabou Harbour, an extension of 260 feet has been made to the coal wharf, and a double track laid to the mine. A breakwater wharf, 320 feet long, has been built, to which the Dominion Government are adding an extension 160 feet long. In fair weather both these wharfs can be used for shipping coal.

"The seams standing at a nearly vertical slope are entered by tunnels in the face of the cliff at water-level, by slopes driven every 25 feet along the level, &c. In the seven-feet-six-inch seam, there are 2,100

feet of levels and 1,750 feet of slopes. In the thirteen-feet seam, opened in August, there are 546 feet of levels and 46 feet of slopes.

COAL.

Discovery and development in Nova Scotia

"This property embraces an area of $2\frac{1}{2}$ square miles, in which, according to Professor Hind, there are 4,000,000 tons above water-level, and 12,000,000 below.

Richmond County.

"In Richmond County, some prospecting has been done by the Eastern Development Company on areas owned by them at Little River, but the results have not yet been communicated to the department."

NEW BRUNSWICK.

Discovery and development in New Brunswick.

As may be seen on reference to table 1, the production of coal in this province fell off slightly in regard to tonnage, yet the price obtained was somewhat higher. As in previous years, the production was carried on in a desultory way, work being done by the farmers and settlers of the vicinity when they could spare time from their other pursuits. The coal mined, finds a market in Fredericton and St. John and various points along the St. John River, a small quantity being utilized by the Central railway running between Hampton and Grand Lake. Many attempts have been made to mine the coal of the province on a systematic and more extensive scale, all of which have, however, fallen through.

NORTH-WEST TERRITORIES.

Discovery and development in North-west Territories.

The production throughout the North-west Territories during the year, shows in quantity and value a marked increase over that of the year previous, the actual increase in quantity being 54,025 tons, or about 30 per cent.

As in previous years, the collieries producing the most extensively were those at Lethbridge, Canmore and Anthracite, while smaller quantities were produced from the mines at Edmonton, Medicine Hat and Estevan.

Regarding operations throughout the North-west Territories, the only information available is that contained in the report of the Superintendent of Mines for Manitoba and the North-west Territories for 1893.

COAL. **British Columbia.**

Discovery and development in British Columbia.

There was a marked increase in the production of coal during 1893. As may be seen on reference to the following tables, the production for the year as compared with that for 1892, shows an increase of 170,194 tons or over 18 per cent.

The following tables, Nos. 11, 11a and 11b, and notes regarding the industry are obtained from the report of the Minister of Mines of the province :—

Coal.

Table 11.

British Columbia.

Production, Sales, etc., for 1892.

Name of Colliery.	Coal raised.	Sold for Home Consumption.	Sold for Exportation.	On hand Jan. 1st, 1892.	On hand Jan. 1st, 1893	Number of Men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo.......	485,392	145,632	344,538	9,949	5,171	1,367
Wellington.....	325,216	62,789	267,008	11,760	7,177	815
E. Wellington.	37,688	5,992	31,360	....	336	152
Union..	77,199	5,356	74,542	15,523	12,824	520
Total........	925,495	219,769	717,448	37,232	25,508	2,854

Coal.

Table 11a.

British Columbia.

Production, Sales, etc., for 1893.

Name of Colliery.	Coal raised.	Sold for Home Consumption.	Sold for Exportation.	On hand Jan. 1st, 1893.	On hand Jan. 1st, 1894.	Number of Men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo	525,629	145,042	379,766	5,171	7,281	1,279
Wellington	377,814	46,056	330,637	7,177	1,120	983
E. Wellington.	30,768	8,400	22,705	336	....	140
Union.........	161,198	33,015	128,079	12,824	12,928	442
N. Thompson..	280	280	....	....	....	....
Total......	1,095,689	232,793	861,187	25,508	21,329	2,844

COAL.

Discovery and development in British Columbia.

COAL.
TABLE 11b.
PRODUCTION, SALES, ETC., FOR 1894.

Name of Colliery.	Coal raised.	Sold for Home Consumption.	Sold for Exportation.	On hand Jan. 1st, 1894.	On hand Jan. 1st, 1895.	Number of Men employed.
	Tons.	Tons.	Tons.	Tons.	Tons.	
Nanaimo......	441,980	121,396	323,826	7,281	4,039	1,178
Wellington....	422,191	56,185	341,434	1,120	25,692	986
Union....... ..	270,336	8,089	261,699	12,928	13,476	765
Total.......	1,134,507	185,670	926,959	21,329	43,207	2,929

The collieries in operation during 1893 were as follows :—

Nanaimo Colliery..........	New Vancouver Coal Mining and Land Co., Ltd.
Wellington Colliery..........	Messrs. Dunsmuir & Sons.
East Wellington Colliery....	East Wellington Coal Company.
Union Colliery.............	Union Colliery Company.
North Thompson Colliery....	Kamloops Coal Company, Ltd.

The product of the latter colliery is used locally, finding a market in and around Kamloops, while from the others the coal is shipped at the ports of Nanaimo, Departure Bay, and Union near Comox, all on Vancouver Island. Of the coal shipped, the greater part went to the ports of San Francisco, San Pedro and San Diego in California. Shipments were also made to Alaska, Hawaii and Petropauloski.

As illustrating the market for British Columbia coal in California, the following figures of imports for 1893 and 1894 are given below :

	Tons.
British Columbia....................	490,679
England............................	110,363
Scotland...........................	17,762
Wales..............................	36,685
Australia..........................	155,415
Puget Sound........................	444,493
Oregon.............................	31,550
Eastern States.....................	16,667
Alaska.............................	200
Japan..............................	7,727
Coal entered in San Francisco in 1893.	1,311,541
do at lower ports, 1893.....	168,244
Total coal entered	1,479,785

COAL

Discovery and development in British Columbia.

	Tons.
British Columbia	649,110
Australia	211,733
English and Welsh	157,562
Scotch	18,636
Eastern, Cumberland, and Anthracite	16,640
Seattle, Franklin, and Green River	153,199
Carbon Hill and South Prairie	241,974
Mount Diablo and Coos Bay	65,263
Japan, &c	15,637
Total for the year 1894	1,527,754

The following notes regarding the various collieries are taken from the report of the Minister of Mines for 1893 :—

Nanaimo Colliery, No. 1 Shaft, Esplanade, Nanaimo.—" No. 1 shaft, situated on the esplanade in Nanaimo, is the most extensive coal mine in the province and has proved to be a most valuable mining property. The shaft is 650 feet in depth with a level driven to the north, known as No. 1 north level, and about 50 yards in this level there is a slope driven in an easterly direction for about 1,000 yards. At about 600 yards down the slope the No. 3 north level branches off. All the workings of these two levels are under the water of Nanaimo Harbour, except the workings of the back end of No. 1 level, which is now working under Protection (or Douglas) Island. The workings of this mine are dry, but not dusty. They are quite safe from any influx of water as there is a thickness of from 500 to 700 feet of débris and hard rock between the bottom of the harbour and the workings of the mine. All the workings are on the pillar and stall system, leaving large pillars of coal.

" The workings of No. 1 north level extend (as mentioned above) under Nanaimo Harbour and Protection Island, and the level is, with its windings, 4,000 yards to the face from the shaft bottom, being the longest underground hauling road in this district. For the long stretch of about two miles, the coal has been very good, varying in thickness from 5 to 10 feet, except in some small spots. At the face the roof is generally good. All the mining from the level is to the west side (other than a slope referred to in a previous report to connect with the Protection Island shaft, which was done on January 22nd, 1893), the coal on the east side being to the dip, and this coal is left to be worked from No. 3 north level and Protection Island shaft, where they are now working.

" No. 3, north level, branching from the main slope, is now in one and a half ($1\frac{1}{2}$) mile from the slope, where it connects with Protection

Island shaft workings in a slope from about 100 yards south of the shaft going east. There are 22 stalls working from this No. 3 level going towards No. 1. The coal is very excellent in quality and varies from 6 to 10 feet in thickness without any plies of rock. All this working will terminate at No. 1 level. Here, in No. 3, the same as No. 1 level, it is all solid to the east side, but at present they are putting two slopes into the solid coal, one of them about half way in No. 3 level, where the coal is 6 feet thick. The other slope is at the place where they connected with Protection Island shaft works. At this place the coal is also 6 feet thick, so that there are splendid prospects for coal to the east side, and quality and appearance keep good. Ventilation is amply sufficient. The mine is now ventilated from Protection Island shaft, on the separate split system, there being three main divisions, near to the bottom of the shaft.

COAL.
Discovery and development in British Columbia.

"The motive power to keep this large volume of air constantly in motion, is a large Guibal fan, erected on the surface near the No. 2 shaft, being the upcast shaft near the No. 1 shaft. The fan is 36 feet in diameter, by 12 feet wide, and gives the above result from Protection Island shaft, not including what goes down No. 1 shaft, which latter I never found less than 32,000 feet per minute. All this air is kept in motion with 40 revolutions per minute, water gauge $1\frac{5}{10}$ inches. And if required this fan can be worked with safety up to nearly double what it is now working at.

"In the levels mentioned, the New Vancouver Coal Company has been hauling the coal out by electricity, which has been found to be a success. The Edison General Electric Company supplied and fitted up the whole of the plant. The dynamos are fixed on the surface and driven by a steam engine built for that special purpose, about 100 feet from No. 1 shaft, occupying a fine building or power-house. From the dynamos the electric current passes to and through all the different instruments to protect the plant against accident and everything that it is possible to work insulated is covered to protect against accident to any person that may be passing the wires, which are strung up in No. 1 level for two miles, this being the distance that the electric locomotive goes. In No. 3 level the locomotive goes fully one mile from the slope, or about one and one-half mile from the shaft. The usual rate is about 6 to 8 miles an hour, taking along, generally, about 40 tons at a time. There are four electric locomotives, three of them are eight tons each and of 30-horse power, these three are at work, one in No. 1 and two of them working in No. 3 level, the smallest one, of 15 horse-power, is on top."

COAL.

Discovery and development in British Columbia

Nos. 1 and 2 Southfield Mines.—These mines are now abandoned and all plant, rails, cars, &c., removed, as all the coal convenient for mining has been taken out.

No. 3 Pit (Chase River).—This mine also was abandoned during the year after drawing all available pillars. It is not the intention to re-open here.

No. 5 Shaft, Southfield.—This shaft is to the dip of Nos. 2 and 4 (Southfield) mines, with the latter of which it is connected. At this point great trouble has been met with through faults, &c., the coal in places measuring twenty-four inches and less, though the seam has a fair average thickness of good coal. Work was carried on here as usual.

Protection Island Shaft.—"This shaft is the deepest in the district; to the lower, or what is called the Newcastle seam, it is 740 feet, with sump 750 feet.

"The upper coal is a continuation of the Douglas seam from No. 1 shaft, and is now connected both with No. 1 and No. 3 levels.

"In No. 1 level they went through on a slope that had been put down 300 yards in good coal; and to get communication with No. 3 level they had to put down a slope from this shaft 200 yards, this being all good coal from the above distance. This slope is now down from the shaft to the east 500 yards in good coal for that distance, most of it being 6 feet thick. This slope branches off to the south, about 100 yards from the shaft. There is another slope from the level on the north side, going north-east, which is now down 250 yards. This is also in good coal, but only 3½ feet thick, good and hard. This is going to be the great highway to the coal underlying the north-east side of Protection Island, Northumberland Channel, and the Gulf of Georgia, and may yet have a connection with Gabriola Island. This may seem a long way off, but a few years ago the same might have been said about Protection Island, from No. 1 shaft. Now, however, we can walk to Douglas (or Protection) Island, and before long we may be able to walk from Nanaimo to Gabriola Island, as there is no reason to doubt that the coal extends to the latter island, which is only two miles away.

"The area of coal opened out here is very large. There are places enough to put on over 100 miners to work. All these places have been at a stand since the 1st September; but I hope to see this extensive mine in operation again soon.

"Protection Island Lower (Newcastle) seam of coal is 62 feet below the Douglas seam. They have done a considerable amount of mining, principally in the way of exploring to find out as to its regularity. The chief opening is by a slope to the east. This is down 350 yards in

good coal for all that distance, and from $3\frac{1}{2}$ to 4 feet thick, of a good quality and is very hard. There were two levels started, but only got in a short distance when they suspended work for a time. The seam kept getting easier to work as they went down, having a strong rock roof. Everything about the top is fitted up in first-class style. Large double hoisting-engine; pit head gear; bunkers; in fact, all appliances that are necessary for the handling of a large output of coal; and to complete the whole, the company has built a large wharf, about 400 feet from the shaft, where they can load the largest ships that come to the harbour."

COAL.

Discovery and development in British Columbia.

Northfield Mine—"This mine is entered by a shaft, as are now all the mines of this colliery, the workings extending to the north and south, by a level on the south and a slope on the north side.

"The coal is worked on the long-wall system; and averages not more than 2 feet 4 inches in thickness, but of very good quality and very hard, so that it stands handling well, and commands the highest price both in Victoria and the California market, and any other place where it has been introduced as a household coal; but owing to the thinness of the seam and the loose nature of the roof, it makes it very expensive coal for the company to produce. Ventilation is good, and on the separate split system."

Harewood Estate.—A considerable amount of prospecting work, consisting of tunnelling and boring, was done on this property as yet with but slight success.

Northfield Estate.—The company sank two diamond-drill holes on this estate finding coal of the usual quality, but of a less thickness than was expected.

Wellington Colliery—No. 1 Pit.—"This is the shaft mentioned in a previous report as near to Departure Bay. In this shaft the owners were having work done at one of the upper seams of coal, in connection with two thick beds of fire clay. They have only worked a short time here during the past year. At present there is nothing being done; the shaft is nearly filled with water, so that this place is in reserve for some future operations."

No. 3 Pit.—"There has not been any mining done here in the past year, pumping having been done all the time in connection with No. 4 pit. There is yet a large quantity of coal to be got from this mine."

No. 4 Pit.—This pit was during the year pumped free from water which had been let in from the Millstone River through pit No. 3 to quench a fire in that part of the mine. It has been cleaned and is being actively worked. The coal is good.

COAL.

Discovery and development in British Columbia.

No. 5 Pit.—"No. 5 pit is the greatest producing mine in the Wellington Colliery. The coal is brought to the bottom of the shaft from the west side by a self-acting incline; from the east level and east slant, on the tail-rope system of haulage. This is 1,100 yards long, and is near the boundary of Northfield (Nanaimo Colliery). This coal is very good and hard, from 3 to 10 feet thick. All down this section is worked by way of pillar and stall, leaving about two-thirds of the coal in the pillars, which are taken out after the stalls are finished. Close to the bottom of the shaft there is a slope, the general bearing of the workings of this is to the east, towards the No. 1 shaft, near Departure Bay. The coal this way is very good and hard, for which a ready sale is found even in these dull times for all that can be got out. The coal is hauled from the lower works here to the bottom of the slope by compressed air, on the tail-rope system of haulage, which—that on the east level and on this—works well. All the mining down here is now done on the pillar and stall system. All the mining in the south side, or west incline, is at the pillars (of coal). Ventilation is good: motive power, a Guibal fan, worked by steam engine."

"There is now very little gas found in this mine. Occasionally gas is found in caves from the roof, and sometimes in a stall. This mine is free from dust. In addition to the manager, there are the overman, fireman, and a staff of shot-lighters to each district in the mine, moving round from one place to another, so that the smallest change in any part of their particular district, or anything going wrong in the air-way, is sure to be found out soon by some one, when it would be reported to the proper authority. This pit is also connected by a travelling road with No. 6 pit, with hand-boards showing the way.

"Here, as in No. 1 shaft of Nanaimo Colliery, the bottom of the pit and round about it is lighted by electricity. This mode of lighting, and the use of electric power for coal cutting, pumping, and for locomotives in hauling coal underground, is now becoming quite an important factor in the use of machinery in our mines."

No. 6 Pit.—"This pit is mentioned in a previous report as being 900 yards from No. 4 pit, but the workings are only separated by a narrow strip of solid coal of about 40 yards thick, which is known as the barrier between the two mines. It was put to a severe test by the filling of the workings of No. 4 pit with water to about 107 feet up the pit, yet with all that pressure it did not show any appearance of leakage, after standing that way for months. This mine (No. 6) is connected with No. 5 pit, but only in one place, and this place is fixed so that it could be blocked as to be able to stand a great pressure. This is done in order, in case of accident to either of the two mines,

that it may serve the same purpose as the barrier served between Nos. 4 and 5 and Nos. 4 and 6 pits. COAL.

This No. 6 pit is quite an extensive mine. Most of the mining being done is to the east, and in a northerly direction towards the workings of No. 5 pit. In this mine, as in all the mines of the Wellington Colliery, the coal is hard, of good quality, and greatly in demand in the California market. There has been much of the coal worked here on the long-wall system during the past year, but now it is all worked on the pillar and stall system, and at the pillars (of coal). The roof is much stronger than in most of the mines of this colliery, and therefore the pillars of coal can be taken out to better advantage. Ventilation is good; the motive power is a fan on the Murphy principle, worked by a steam engine. Although this pit is connected with No. 5 pit, it is independent of it so far as ventilation is concerned, there being a close partition in this shaft, one side being the intake and the other the upcast for ventilation purposes. This pit is also free from dust." Discovery and development in British Columbia.

No. 2 Slope.—No work was done here during the year.

Alexandra Mine.—No work was done here during the year.

Between No. 1 pit and the workings at No. 5 pit two bore-holes were sunk by the owners, which show that the coal is continuous between these two points.

East Wellington Colliery.—From January to October this company produced 30,768 tons of coal when, owing to the low price obtained and the proportionately high cost of production, work was discontinued. All cars, rails, pumps, &c., were brought to the surface and the mine abandoned.

Union Colliery, Comox, No. 1 Shaft.—No work was done here during the year beyond clearing the shaft and workings of water. It is the intention to continue mining as soon as the mine is clear.

No. 1 Slope.—"This is now the most extensive mine of the colliery. As in the other mines, there has been idle time here; but they kept driving the slope ahead so that its length from the entrance, under cover, is now 4,300 feet (with 700 feet further to where the engine stands), making it the longest slope in the district, with good hard workable coal the entire distance that the slope is down, and at the bottom there is no falling off, as the coal looks as well, and if anything, is better as it goes down. In the first 400 yards of the slope it is so flat that they have to haul out the coal by the tail-rope system, but after that distance there is a nice easy grade enabling the empty cars to take the rope down, and of course the engine can haul it up, and when it gets the cars to the flat it is again hooked on.

COAL.

Discovery and development in British Columbia.

"From this slope, nine levels have been started to the east side, and as many to the west side. At present, owing to the slackness in the coal trade, they are only working Nos. 6, 7, 8, and 9 levels, on the east side, employing about 60 men on one shift, with coal averaging about five feet thick, although in most of the places it is much thicker and very hard. On the west side of this slope they are at present doing all their mining from Nos. 7, 8, and 9 levels. Here, as in the east side, the coal is very good but much thicker, employing 40 men on one shift; but if the coal trade demand it, they could almost find places for double that number on both sides of the slope. At present they are getting out about 800 tons of screened coal from this mine alone; and if trade should justify it they could, with No. 1 shaft, No. 1 slope, and this No. 4 slope, under the present condition, almost put out 2,000 tons of marketable coal per day. Ventilation is good. Motive power is a Guibal fan, which running slow passes 50,000 cubic feet of air per minute."

Nos. 1 and 2 Tunnels.—These tunnels or adit levels were not worked during the year and all rails and plant were taken out. As the roof is secure and natural drainage good, the mine and coal, of which a large quantity remains in the property, will not be injured by remaining idle.

Tumbo Island Coal Mining Company.—"This company has been doing considerable work during the past year at the island, principally in sinking the shaft. Here they have had stoppages in many ways. The greatest drawback has been that they had too much water for the machinery in use. They worked up to the 28th August, when the depth of 245 feet was reached. At this point the water exceeded the power of the appliances for taking it out, and since then there has not been any work done in the bottom, and they are yet fully 100 feet from the coal. At the bottom where they left off they were in dark shale, and the rock will be soft until the coal is reached; but before they can resume operations in the shaft new appliances for raising the water must be placed in position, powerful enough to keep the shaft clear of water so that the miners may be able to work. If they had the proper machinery it would take only a comparatively short time to win the coal. The company have on the ground at the shaft, one stationary engine, four steam pumps, also an air compressor, and when working there were 21 white men employed."

The Nicola Valley Railway Company.—The occurrence of coal of good quality near the confluence of the Coldwater and Nicola rivers, has been known for many years. The natural outcrops and small openings made at that time are described in the Report of Progress of the Geological Survey for 1877-78 (p. 122B). Since the construction

of the Canadian Pacific, this field has been brought within forty miles of a railway and more interest has been felt in the coal deposits. As, however, their utilization on any important scale would involve the building of a branch line of some length, it became important to further test the character and extent of the coal seams. The following particulars of boring operations are abstracted from the report of the provincial Minister of Mines for 1893.

COAL. Discovery and development in British Columbia.

The Nicola Valley Railway Company having secured from the settlers of the valley all their coal rights, with the addition of legislative right of way, attention was turned to the exploration of the coal. A diamond drilling machine was employed in boring at a spot, about half a mile to the dip of the crop-out, and here the coal was struck at the depth of 190 feet, and proved to be about 5 feet 7 inches thick. The hole was continued to the depth of 600 feet. Several other smaller seams were gone through before gaining that distance, and when the whole was stopped they were still in the productive coal measures. All the coal gone through, as well as what is seen at the crop-out, is very hard, and those who have tested it report it to be of a superior quality.

The drilling machine was then removed and another hole was put down two miles further up the valley. At the depth of 137 feet from the surface coal was struck,about 5 feet 6 inches thick. The whole was continued to the depth of 562 feet, having gone through some smaller seams of coal, thus proving that the valley has underlying it a large deposit of superior coal.

The Kamloops Coal Company, Limited.—"This enterprising coal company did considerable work in and about their mine on the North Thompson River, during last winter and spring. A quantity of coal was taken out for consumption in Kamloops, in order to thoroughly test the quality of it. About 250 tons were taken into Kamloops, and it is used there exclusively for domestic purposes, except where hard coal is required. The mine is not now in operation."

A description of this coal field was given by Dr. G. M. Dawson in his report for 1877, pp. 112B to 114B, and further notes by Mr. McEvoy will be found in the Summary Report of the Geological Survey for 1892, p. 10.

COKE.

COKE.

The production of oven coke during the year amounted to 61,078 tons, valued at $161,790, showing a slight increase over that of the year previous.

Coke.

The annual production for the past eight years was as follows :—

1886..........	35,396 tons, valued at	$101,940
1887..........	40,428 "	135,951
1888..........	45,373 "	134,181
1889..........	54,539 "	155,043
1890..........	56,450 "	166,298
1891..........	57,084 "	175,592
1892..........	56,135 "	160,249
1893..........	61,078 "	161,790

The production for 1894 was as follows :—

1894.......... 58,044 tons, valued at $148,551

The production of oven coke given above was until 1894 altogether that of Nova Scotia, in which province it is all used at the various iron furnaces and works. Returns were received, however, of a small quantity of coke manufactured at the British Columbia mines in 1894.

The imports of oven coke are shown in the following table :—

Imports of coke.

Coke.

Table 1.

Imports of Oven Coke.

Fiscal Year.	Tons.	Value.
1880..........................	3,837	$ 19,353
1881..........................	5,492	26,123
1882..........................	8,157	36.670
1883..........................	8,943	38,588
1884..........................	11,207	44,518
1885..........................	11,564	41,391
1886..........................	11,858	39,756
1887..........................	15,110	56,222
1888..........................	25,487	102,334
1889..........................	29,557	91,902
1890..........................	36,564	133,344
1891..........................	38,533	177,605
1892..........................	43,499	194,429
1893..........................	41,821	156,277
1894..........................	42,864	176,996

There are, of course, large quantities of gas coke produced annually, all of which finds a ready local market for domestic and other purposes ; but it has not been found possible to obtain full or accurate returns of this product.

COPPER.

Copper.

Production.

The production of copper in Canada for 1893, shows an increase over that of last year of more than fourteen per cent in quantity and over five per cent in value. The figures for the past years to 1893 are given below :

1886	3,505,000 lbs.,	valued at	$354,000
1887	3,260,424	"	342,345
1888	5,562,864	"	667,543
1889	6,809,752	"	885,424
1890	6,013,671	"	902,050
1891	8,928,921	"	1,160,760
1892	7,087,275	"	826,849
1893	8,109,856	"	875,865

The above production, represents as formerly, shipments of ore, &c., resulting from mining operations in the provinces of Quebec and Ontario in the Capelton and Sudbury districts respectively. No copper was produced and shipped from the other provinces except, perhaps, that some of the gold and silver ores shipped from British Columbia may have carried a small amount of copper, but the quantity must have been very small, and it has been found impossible to get any data regarding it.

In valuing the copper contained in the shipments of ore the average market price for the year is taken, to bring it to a uniform basis with the other metals. The spot value of the ore and matte shipped, however, is of course lower, and varies much, depending upon the extent to which the process of treatment for extraction of the useful metal has been carried.

This varies considerably according to the local conditions and the policy of each mine and operator. No copper, the product of Canadian mines, is at present exported in the metallic state. Thus the shipments of copper bearing material are represented by the following figures :—

Raw ore—50,702 tons carrying from 3 to 4 per cent of copper.

Matte — 9,800 " 15 to 20 " "

For 1894 the figures of production include the copper contained in the gold or silver bearing copper ores of British Columbia, which in this year first became an important item. The details are as follows :—

Quebec	2,176,430 lbs.	valued at	$206,761
Ontario	5,207,679	"	494,730
British Columbia	352,907	"	33,526
Total	7,737,016		$735,017

COPPER.

Exports and imports.

The data regarding exports and imports for 1894 and previous years are given in the following tables, Nos. 1, 2 and 3, whilst the fluctations in the price of this metal are shown in the general price table attached to this report.

COPPER.

TABLE 1.

EXPORTS, OF COPPER IN ORE, MATTE, ETC.

Year.	Nova Scotia.	Ontario.	Quebec.	British Columbia.	Total.
1885			$262,600		$262,600
1886		$ 16,404	232,855		249,259
1887		3,416	134,550		137,966
1888			257,260		257,260
1889			168,457		168,457
1890		2,219	396,278		398,497
1891		64,719	283,385		348,104
1892	$100	79,141	198,391		277,632
1893		212,314	56,846		269,160
1894		25,029	12,005	54,883	91,917

COPPER.

TABLE 2.

IMPORTS : PIGS, OLD AND SCRAP.

Fiscal Year.	Pounds.	Value.
1880	31,900	$ 2,130
1881	9,800	1,157
1882	20,200	1,984
1883	124,500	20,273
1884	46,200	3,180
1885	28,600	2,016
1886	82,000	6,969
1887	40,100	2,507
1888	32,300	2,322
1889	32,300	3,288
1890	112,200	11,521
1891	107,800	10,452
1892	343,600	14,894
1893	168,300	16,331
1894	101,200	7,397

COPPER.

TABLE 3.

IMPORTS : MANUFACTURES.

Copper. Imports.

Fiscal Year.	Value.
1880	$123,061
1881	159,163
1882	220,235
1883	247,141
1884	134,534
1885	181,469
1886	219,420
1887	325,365
1888	303,459
1889	402,216
1890	472,668
1891	563,522
1892	422,870
1893	458,715
1894	175,404

DISCOVERY AND DEVELOPMENT.

NOVA SCOTIA.

Discovery and development in Nova Scotia

The only work done in this province was at the Coxheath Mine in Cape Breton, where a small force of men was doing development work. The owners have in contemplation the erection of smelting works on the North-west Arm of Sydney Harbour, where they believe that their ore can be profitably smelted by bringing suitable ores for mixing from other places where such are known to exist, possibly from Newfoundland, and utilising the product of the adjacent coal fields for fuel.

Regarding this and other points, the company reports as follows* :

"The unexpected change in general financial situation all over the world prevented this company from carrying out plans for 1893. The main slope (No. 2) was unwatered in April and the following mining development work done. On the 190 ft. level the vein was under-stoped for 71 ft. in length, 10 ft. in width, and 12 ft. in depth, yielding about 600 tons of ore averaging 10 p.c. copper, from which a ton was forwarded to Chicago and added to the Nova Scotia exhibit at the World's Exposition. On the 250 ft. level the drifts were extended 45 ft. On the lower or 320 ft. level 86 ft. of continuous drifting was done, the vein yielding a very good grade of ore. Total amount of ore raised from shaft No. 2, 1,250 tons. The hoisting engine has been thoroughly overhauled and repaired. An

* Report of Provincial Department of Mines for Nova Scotia, 1893.

COPPER.

additional No. 4 Blake steam pump purchased. The residence for the mining captain and staff completed.

Discovery and development in Nova Scotia

"Preparatory to building permanent works, the company has purchased 522 acres of land covering sites for mining operations, concentration mill and a reservoir for ample water supply for the mill.

"At Watson's Point, on the North-west Arm of Sydney Harbour, the company has purchased the Grantmyer farm and a portion of the Watson farm, in all 325 acres, with a water front of 2,300 feet. The main smelting works are designed to be built on the 20 acres lying between the Cameron road and the water front. The Intercolonial railroad runs through this property. Watson's Brook can furnish ample water supply and the rear land contains a large quantity of good timber. The location is connected both by rail and water with the coal fields of Cape Breton county.

"Amount of work performed during the year is as follows:—

"Skilled labour above ground	1,020	days.
" underground	1,177	"
"Unskilled labour above ground	910	"
" underground	836	"
"One horse team and man	413	"
	4,356	days."

Discovery and development in Quebec.

QUEBEC.

The copper produced in this province was altogether contained in the pyritous ores mined in the vicinity of Capelton near Sherbrooke. These ores carry from three to four per cent of copper, but are primarily used as a source of sulphur in the manufacture of sulphuric acid, the industry "according to our returns" employing altogether about 530 men.

The industry presents no new features from those described in our previous reports. The Nichols Chemical Company shipped part of their product as raw ore to their chemical works at Laurel Hill, New Jersey, U.S.A., and burned the rest at their acid works at Capelton, the resulting cinder being put through their water jacket furnace and the matte thus produced, containing about fifty per cent of copper, was shipped to the United States.

The Eustis Company shipped all their ore raw to different points in the United States (Buffalo, Cleveland, Boston, New York, &c.)

The Moulton Hill Mine of the Grasselli Chemical Company, was temporarily shut down, but they operated their Howard Mine, shipping the ore in the raw state to their works at Cleveland, Ohio.

COPPER.

ONTARIO.

Discovery and development in Ontario.

In this province, the industry presents much the same features as last year. The only metal shipped was contained in the nickel-copper matte from the Sudbury mines.

Sudbury.—The same operators as last year were active in 1893, viz., The Canadian Copper Company, The Dominion Mineral Company, and Messrs. H. H. Vivian & Company. As the mode of work at these mines has been fully described in previous reports nothing more need be said here. The number of men employed during the year at the various mines and works, according to our returns, was about nine hundred. The product was shipped in the condition of matte containing from 15 to 20 per cent of copper.

Mamainse.—At this place the Copper Creek Mining Company of Detroit continued the development of their property with a force of about twenty men under the direction of Captain T. H. Trethewey. The property comprises two locations on the eastern shore of Lake Superior, which were first acquired about the year 1842 by the old Montreal Mining Company, and subsequently transferred to the Ontario Mineral Lands Company, which also owned the well-known Silver Islet Mine on the Lake. The two locations on which the present work is being done, comprise some 11,200 acres, located upon the area of Keeweenian rocks constituting the Point Mamainse district, and is adjacent to that owned by the Lake Superior Native Copper Company, where extensive work was carried on from 1880 to 1885. The copper deposits of the formation are of two kinds, viz., fissures cutting the formation and carrying either native copper or sulphuretted ores of that metal or both, and amygdaloidal trappean beds, carrying native copper.

Captain Trethewey kindly furnishes the following data regarding the work done by the Copper Creek Company :—Plant and machinery, one double cylinder steam hoisting engine of 30 horse-power ; four drill air compressor and power drills ; duplex pump, etc., with 40 horse-power boiler ; also one Sullivan Diamond drill, boiler, etc., complete of 700 feet capacity. The developments made to the end of 1893 were as follows, viz. :—One shaft, size 7 x 14 feet, sunk on a fissure vein to a depth of 308 feet, with pumping station and one drift. This shaft for nearly 100 feet was sunk through ground carrying native copper and "gray ore" (chalcocite) and proved the vein to average fully five feet in thickness and to average over 12½ per cent of metallic copper. For the next fifty feet sunk through, the vein proved less productive, after which to the bottom (308 feet) the vein in the shaft yielded copper ores, principally chalcocite, assays from some of which are as follows :—

COPPER.

Discovery and development in Ontario.

Gold (approximately)............	$ 3.20 per ton
Silver........................	26·85 oz. "
Copper.......................	62·80 per cent

(Valued at $142.72 per ton.)

The vein in the shaft is composed of crushed portions of wall rock, conglomerate and amygdaloid intermingled with calcspar and quartz.

Pits and surface cuts on the line of the same vein for a distance of 1,000 feet show rich chalcocite and native copper, whilst pits on other veins show satisfactory evidences of copper. About 3,600 feet of holes were bored with the diamond drill at various points inland.

No shipments were made, as the only work done was exploratory and but a small amount of ore fit for shipment without concentration would be thus obtained. About 25 tons of ore, however, averaging 18 per cent of copper to the ton, were thus obtained and stored at the mine.

Discovery and development in British Columbia.

BRITISH COLUMBIA.

Copper mining in this province remains about as in the past, the copper produced being contained in ores mined primarily on account of their contents of the precious metals.

Work has been done on numerous claims throughout East and West Kootenay, whose ores carry a greater or less percentage of copper. The ores of the Trail Creek and Toad Mountain camps are specially notable in respect of their copper contents, and the shipments made from these points during the year would represent therefore a certain production of copper, the amount of which it has, however, been impossible to obtain for 1893. Assessment work was done on many other similar deposits, and the report of the Minister of Mines for the province speaks of an interesting deposit having been located in September in the Fish Creek district, the ore assaying, beside silver and gold, twenty per cent copper. In the same report, mention is made of reported discoveries as follows:—Of a promising body of copper carbonate on the Canal claim on the east side of Columbia Lake, Thunder Hill Camp, East Kootenay district; of copper-bearing ores at the head of St. Mary's River, ore from one vein on the South Fork assaying thirty-one per cent of the metal; at Bull River Cañon, of a twenty-two per cent ore of the metal; at Sand Creek of copper glance, and at Kinbasket Lake and other places, all in the same district.

In Yale district assessment work was done on the copper claims at Copper Creek on the north shore of Kamloops Lake, and a discovery was made of a very large vein on Fall Creek in the vicinity of Adams Lake carrying copper and silver ores.

Some copper ores are reported as occurring along the survey line of the Esquimalt and Nanaimo railway. Mr. Ralph, speaking of this says that in the pass between Mount Grey and Mount Spencer, at the head of Franklin River, are several quartz veins from six to eight inches wide, rich in yellow copper ore, with indications of copper ores from the sixty-seventh to the sixty-eighth mile-post near Alberni Canal; also that at a place about two miles north-east of the 115-mile post, at an elevation of 6,000 feet, on the packers trail in the mountain pass at the head of the west branch of Cruikshank River are some mineral veins fifteen feet thick containing iron, copper and perhaps silver.

COPPER.

Discovery and development in British Columbia.

Texada Island.—On Texada Island some test work was done on a copper ore vein by the Minerva Marble and Mining Company, regarding which Mr. Alfred Raper sends us the following information:— The New Comstock Lode, as they have named it, lies about 2,000 feet north-west from the Puget Sound Iron Company's iron mine. In the shaft sunk to a depth of some thirty feet, the vein at six feet deep showed forty inches thick of sulphide of copper, at a depth of twenty-five feet the ore rib had narrowed down to three inches thick, thence downward, it widened again until it measured two feet of ore at the bottom of the shaft. The lode strikes north and south and dips to the west at an angle of about 75°, having limestone on the foot-wall and syenite on the hanging-wall. It is claimed to have been traced on the strike and tested by openings for 1,200 feet. The same gentleman reports work done in the same vicinity by the Texada Gold and Silver Mining Company, which has three copper veins on its property, work so far having been mostly done on that known as the Little Gem Lode upon which two shafts have been sunk. From the new shaft, thirty-three feet deep, some thirty tons of ore have been obtained and stored in the dump. Specimens of this ore yielded respectively :

	I.	II.
Copper......	37 per cent.	15 per cent,
Silver.......	4 oz.	15 oz.

The local government report publishes an excellent study of the specimens of ore collected by their agents for exhibit at Chicago by Mr. W. Pellew Harvey, who made assays of all for them. Speaking of copper ores, his reports says :—" The signs of the existence of copper in this district (East Kootenay) are numerous and encouraging. We have carbonates, sulphides and oxides of this metal, as well as in combination with antimony, in which case the silver contents run exceedingly high. The Windermere Mountain deposits and also those of the Spallumcheen are very interesting, producing good smelting ores. The former carry it as red oxide and carbonate, and the latter carbonates.

Copper.

Discovery and development in British Columbia.

From Jubilee Mountain we have splendid showings of purple copper ore, the assays in each case covering a range of from 35 to 59 per cent and there are instances outside of the collection sent to Chicago where even higher results than these have been obtained. In a few cases where the ore carries sulphide and a consequent decrease in the percentage of the metal contained, a little trouble and expense would be the means of eliminating the excess of sulphur and placing on the market parcels of such ore as would pay handsomely to ship." Other copper occurrences are mentioned as follows: "There was one sample of copper ore ('peacock') from the Silver Bow (Illecillewaet district) which struck me as being a particularly beautiful specimen carrying gold, silver and copper in heavy quantities." "The Silver King (Toad Mountain camp) argentiferous copper with silver 444 oz. and 23·50 per cent copper requires no further mention." "Trail Creek—sixteen specimens composed this exhibit. They contain various quantities of gold, silver and copper. The ore is a yellow sulphide and should be treated and converted into matte on the spot. The extent of the deposits and the gold contained should make these ores valuable apart from copper. I should expect to find nickel in such ore." "Kamloops—One sample of copper from the Victoria was first-class and carried 60 per cent of the metal." "Osoyoos district—I was particularly struck with the nature of the exhibits from this district. The ores seem to contain silver, gold, lead and copper in paying quantities." In connection with these remarks it must be remembered that whilst they represent the results of an extended and painstaking examination by assay, &c., of a large collection, still these were not *samples*, properly so called, representing some large body of ore, but were *specimens* selected for exhibition to illustrate the nature of the ores.

Graphite.

GRAPHITE.

Production.

Production.

There was no production of graphite during 1893, all the operators of last year having reported nothing done.

The production of past years is as under:

1886	500	tons,	valued at	$4,000
1887	300	"	"	2,400
1888	150	"	"	1,200
1889	242	"	"	3,160
1890	175	"	"	5,200
1891	260	"	"	1,560
1892	167	"	"	3,763
1893	nil.			nil.
1894*	69	"	"	223

* Exports.

Exports and Imports.

GRAPHITE.

Exports and imports.

All data regarding exports and imports will be found in the following tables Nos. 1, 2 and 3. The small amount shown as exported from Ontario in 1893 in table 1 was doubtless of material mined in previous years and held in stock.

GRAPHITE.

TABLE 1.

EXPORTS.

Year.	New Brunswick.		Ontario.		Quebec.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1886	8,142	$3,586	....	....	....	....
1887	6,294	3,017	....	....	....	....
1888	2,700	1,080	....	....	....	....
1889	660	422	22	$116	....	....
1890	400	160	329	1,369	....	....
1891	464	72	....	....	....	....
1892	1,224	449	15	60	4,590	$3,443
1893	....	....	12	38	....	....
1894	....	....	69	223	....	....

GRAPHITE.

TABLE 2.

IMPORTS OF RAW AND MANUFACTURED PLUMBAGO.

Fiscal Year.	Plumbago.	Manufactures of Plumbago.
1880	$1,677	$2,738
1881	2,479	1,202
1882	1,028	2,181
1883	3,147	2,141
1884	2,891	2,152
1885	3,729	2,805
1886	5,522	1,408
1887	4,020	2,830
1888	3,802	22,604
1889	3,546	21,789
1890	3,441	26,605
1891	7,217	26,201
1892	2,988	23,085
1893	3,293	23,051
1894	2,177	16,686

Graphite.

Imports.

Graphite.

Table 3.

Imports of Black-lead.

Fiscal Year.	Value.
1880	$18,055
1881	26,544
1882	25,132
1883	21,151
1884	24,002
1885	24,487
1886	23,211
1887	25,766
1888	7,824
1889	11,852
1890	10,276
1891	8,292
1892	13,560
1893	16,595
1894	17,614

Discovery and development.

Discovery and Development.

No reports of discovery or of development of the numerous known occurrences of this mineral have come to hand for the year 1893. Particulars of these deposits occurring in the Laurentian rocks in Ottawa and Argenteuil counties, Quebec, and in the Kingston and Pembroke railway district in Eastern Ontario having been given already in previous reports need not be repeated here, but in view of the known extent of many of them, this suspension of the industry will doubtless prove only temporary, being in one case caused by failure to complete financial arrangements found necessary in order to work on a larger and more profitable scale.

From New Brunswick, Mr. W. F. Best writes regarding the mine near St. John, that it has been closed for a year on account of the high freight rates on plumbago to points west.

Gypsum.

GYPSUM.

Production.

The figures of production of gypsum for 1893, show a falling off of a little over twenty per cent of the tonnage figures for 1892, as will be seen on reference to the following figures, relatively to this and past years :—

Gypsum.

Production.

1886..........	162,000	tons, valued at	$178,742
1887..........	154,008	"	157,277
1888..........	175,887	"	179,393
1889..........	213,273	"	205,108
1890..........	226,509	"	194,033
1891..........	203,605	"	206,251
1892..........	241,048	"	241,127
1893..........	192,568	"	196,150

For 1894 the production was as follows :—

1894.......... 223,631 tons, valued at $202,031

Tables 1 and 1a, following, show the relative contributions of the various provinces to the grand totals for the years 1893 and 1894.

Gypsum.

Table 1.

Production by Provinces, 1893.

Provinces.	Tons.	Value.
Nova Scotia..................	152,754	$144,111
New Brunswick	36,916	41,846
Ontario	2,898	10,193
Total.... . ...., ...	192,568	$196,150

Gypsum.

Table 1a.

Production by Provinces, 1894.

Provinces.	Tons.	Value.
Nova Scotia..................	168,300	$147,644
New Brunswick.	52,962	48,200
Ontario	2,369	6,187
Totals...	223,631	$202,031

Discovery and Development.

Discovery and development.

This industry shows no features of any importance for the year 1893 needing any addition to the descriptions already given in previous reports.

Gypsum.

Discovery and development.

The operations carried on are still confined to the provinces of Nova Scotia and New Brunswick, where numerous operators work quarries of this material located in various parts of the province, and to the Grand River district in Western Ontario.

Mr. H. Fletcher, in summarising the results of his work in the eastern part of Hants County, Nova Scotia, gives notes on sundry of the numerous gypsum deposits of that district in the Summary Report of the Geological Survey for 1893, pp. 40 to 43.

Exports and imports.

Exports and Imports.

The following tables Nos. 2, 3, 4 and 5 give the exports and imports of the material for the current and previous years.

An examination of table 2 shows a considerable falling off in the exports of the crude mineral, and even with the addition of the $22,132 worth of the ground article, the figures are much below those for last year.

This is accounted for by the business depression in the United States where most of the gypsum is marketed.

Gypsum.

Table 2.

Exports of Crude Gypsum.

Years	Ontario.		Nova Scotia.		New Brunswick.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1874	......	....	67,830	$ 68,164	....	....	67,830	$ 68,164
1875	......	... .	86,065	86,193	5,420	$ 5,420	91,485	91,613
1876	120	$ 180	87,720	87,590	4,925	6,616	92,765	94,386
1877	.... .	....	106,950	93,867	5,030	5,030	111,980	98,897
1878	489	675	88,631	76,695	16,335	16,435	105,455	93,805
1879	579	720	95,623	71,353	8,791	8,791	104.993	80,864
1880	875	1,240	125,685	111,833	10,375	10,987	136,935	124,060
1881	657	1,040	110,303	100,284	10,310	15,025	121,270	116,349
1882	1,249	1,946	133,426	121,070	15,597	24,581	150,272	147,597
1883	462	837	145,448	132,834	20,242	35,557	166,152	169,228
1884	688	1,254	107,653	100,446	21,800	32,751	130,141	134,451
1885	525	787	81,887	77,898	15,140	27,730	97,552	106,415
1886	350	538	118,985	114,116	23,498	40,559	142,833	155,213
1887	225	337	112,557	106,910	19,942	39,295	132,724	146,542
1888	670	910	124,818	120,429	20	50	125,508	121,389
1889	483	692	146,204	142,850	31,495	50,862	178,182	194,404
1890	205	256	145,452	139,707	30,034	52,291	175,691	192,254
1891	5	7	143,770	140,438	27,536	41,350	171,311	181,795
1892	.....	....	162,372	157,463	27,488	43,623	189,860	201,086
1893	......	.. ..	132,131	122,556	30,061	36,706	162,192	159,262
1894	.. ..	....	119,569	111,586	40,843	46,538	160,412	158,124

GYPSUM.

GYPSUM.

Imports.

TABLE 3.

IMPORTS OF CRUDE GYPSUM.

Fiscal Year.	Tons.	Value.
1880	1,854	$3,203
1881	1,731	3,442
1882	2,132	3,761
1883	1,384	3,001
1884	....	3,416
1885	1,353	2,354
1886	1,870	2,429
1887	1,557	2,492
1888	1,236	2,193
1889	1,360	2,472
1890	1,050	1,928
1891	376	640
1892	626	1,182
1893	496	1,014
1894	....	1,660

GYPSUM.

TABLE 4.

IMPORTS OF GROUND GYPSUM.

Fiscal Year.	Pounds.	Value.
1880	1,606,578	$ 5,948
1881	1,544,714	4,676
1882	759,460	2,576
1883	1,017,905	2,579
1884	687,432	1,936
1885	461,400	1,177
1886	224,119	675
1887	13,266	73
1888	106,068	558
1889	74,390	372
1890	434,400	2,136
1891	36,500	215
1892	310,250	2,149
1893	140,830	442
1894	23,270	198

Gypsum.

Imports.

Gypsum.

Table 5.

Imports of Plaster of Paris.

Fiscal Year.	Pounds.	Value.
1880	667,676	$ 2,376
1881	574,006	2,864
1882	751,147	4,184
1883	1,448,650	7,867
1884	782,920	5,226
1885	689,521	4,809
1886	820,273	5,463
1887	594,146	4,342
1888	942,338	6,662
1889	1,173,996	8,513
1890	693,435	6,004
1891	1,035,605	8,412
1892	1,166,200	5,595
1893	552,130	3,143
1894	422,700	2,386

Iron.

IRON.

Production.

The production of iron ore during 1893 was as follows:—

	Tons.
Nova Scotia	102,201
Quebec	22,076
British Columbia	1,325
	125,602

The accompanying graphic table A shows plainly the variations in the production for past years. The increase since 1891 has been very nearly one hundred per cent in the tonnage. A comparison with the figures for 1892 shows a slight increase for the province of Quebec, a large proportional decrease for British Columbia and an increase of nearly fifty per cent for Nova Scotia. The iron deposits of Ontario still remained idle during the year 1893.

Iron.

Production.

IRON.

Annual Production of Ore.

Table A.

Year.	Tons.	Value.
1886	69,708	$126,982
1887	76,330	146,197
1888	78,587	152,068
1889	84,181	151,640
1890	76,511	155,380
1891	68,979	142,005
1892	103,248	263,866
1893	125,602	299,368
1894	109,991	226,611

IRON.
Production.

Table No. 1, following, shows the production of ore for the largest producing province, viz., Nova Scotia :—

IRON.
TABLE 1.
NOVA SCOTIA : ANNUAL PRODUCTION OF ORE.

	Tons.
1876	15,274
1877	16,879
1878	36,600
1879	29,889
1880	51,193
1881	39,843
1882	42,135
1883	52,410
1884	54,885
1885	48,129
1886	44,388
1887	43,532
1888	42,611
1889	54,161
1890	49,206
1891	53,649
1892	78,258
1893	102,201
1894	89,379

Exports and Imports.

EXPORTS AND IMPORTS.

In the following table, No. 2, the export figures appear to be somewhat in contradiction to those of production given above. These apparent discrepancies are, however, probably due to shipments made in 1892, and so appearing in the direct returns for that year, being held in stock *en route* and thus being only entered for export in the year following.

IRON.
TABLE 2.
EXPORTS OF ORE.

Province.	1891.		1892.		1893.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario	2,259	$ 3,932	*10,938	$39,954	1,042	$ 4,083	23	$ 93
Quebec	191	2,683	203	2,324	......	......	......	13,813
Nova Scotia	......	......	......	......	2	6	......	......
Manitoba	......	......	......	......	30	86	......	......
British Columbia	359	4,958	1,986	10,802	1,345	3,415	878	7,388
Totals	2,809	$11,573	13,127	$52,720	2,419	$ 7,590	......	$21,294

*Probably the product of the province of Quebec, shipped via Ontario.

As in past years there are no imports to report.

Discovery and Development.

Iron.

Discovery and development in Nova Scotia.

In this respect the year 1893 showed no very novel features, the old established industries in Nova Scotia and Quebec being continued much on the same lines as before.

Nova Scotia.

The operations carried on in this province were all for the supply of ore to the furnaces of the Londonderry Iron Company; the New Glasgow Iron Coal and Railway Company and the Pictou Charcoal Iron Company. Most of the ore was obtained by the companies from their own mines, although the Londonderry Company bought and used the output of the Torbrook mine situated in Annapolis County.

These four companies employ in all over one thousand men, probably one-third being engaged in mining proper, and the rest around and in connection with the furnaces, coke and charcoal burning and quarrying the limestone for flux, &c.

They each have a complete mining and furnace plant, together with the necessary outfit for providing themselves with coke and charcoal for fuel, the details of which have been given in the report for 1892. Further details will also be found on reference to the report of the Department of Mines of the province for 1893, pp. 38 to 42 and 49 to 52.

Quebec.

Discovery and development in Quebec.

The Quebec iron mining industry was represented by the work done by the Canadian Iron Furnace Company and Messrs. John McDougall & Company on their deposits of bog ore in the province, to supply their furnaces at Drummondville and Radnor Forges. A small force of men was employed for about four months by Messrs. Ennis & Company at Bristol mine in Pontiac county. They shipped a small quantity of ore over the Pontiac and Pacific Junction railway.

At Radnor Forges a new furnace with a capacity of twenty-five tons per diem was blown in. A small quantity of the magnetic iron sand from the north shore of the St. Lawrence was shipped to England for experimental purposes.

It is reported that the Leeds iron mine on lot 7, range V., in Leeds township, Megantic county, has been sold to a company who intend to commence work next year.

Iron.

Ontario.

Discovery and development in Ontario.

Beyond a little prospecting and spasmodic and scattered test work iron ore mining in this province remained a dead letter.

Several reported deposits of iron ores in the townships of Dalton, Digby, Lutterworth and Galway in the counties of Victoria, Haliburton and Peterborough were visited by Dr. F. D. Adams for the Survey. His report on them constitutes part J of volume VI. From his statements it would seem that at most of the points visited the ore did not occur in sufficient quantity to be of economic importance. One is, however, mentioned where several hundreds of tons of ore has been extracted and shipped. This mine is situated on lots 5 in range V. and 5 in range VI. of Lutterworth, but no work had been done for many years.

During his work for the Survey in the district north-west of Port Arthur on Lake Superior, Mr. McInnes visited the iron-bearing range along the Aticokan River, examining it at a number of points, and says that * "although the trenches and test pits, which had been made, were largely filled by caving in, enough was seen to show that there exist along the eastern half of the range, extensive deposits of remarkably rich and pure magnetite. Towards the western end of the range the ore bodies are banded in character and the belts of clean ore are not extensive."

Northern Territory.

Discovery and development in Northern Territory.

Another officer of the Survey, Mr. D. B. Dowling, mentions having observed a deposit of magnetite on a small island in Woman Lake, which is situated in the part of Keewatin in which he was working east of Lake Winnipeg and north of Lake Seul.*

Mr. Tyrrell thus describes an occurrence of ores of iron on Lake Athabasca at its eastern end.* "Near the east end of this outcrop of Huronian quartzite is an extensive deposit of limonite and hæmatite. The point where this deposit was seen was in a hill 125 feet high, the scarped faces of which stand out boldly as high red cliffs. The whole hill is a mixture of quartz and iron ore."

Mr. Low in writing of the country passed through on his Labrador trip mentions* "immense deposits of Cambrian rocks along the Ungava River. These closely resemble the rocks along the east coast of Hudson Bay, and I believe they cover a great area of country about and to the westward of Ungava Bay. They are essentially an iron bearing series as almost every bed holds that metal and some of them are pure hæmatite ore."

* Summary Report of the Geological Survey Department of 1893.

It is interesting in this connection to refer back to Dr. Bell's report on the east coast of Hudson Bay* where he describes the outcropping of manganiferous carbonate ores of iron, apparently of very great extent, along the chain of islands skirting the coast at Nastapoka and Hopewell Sounds.

IRON.
Discovery and development.

BRITISH COLUMBIA.

The Puget Sound Iron Company did not operate during the year, but a small force of men were employed for about three months at the Glen Iron Mine near Kamloops in the district of Yale. The ore mined was shipped to the United States for use as flux by the Pacific coast lead and silver smelters. Owing, however, to a suspension of the demand and there being no smelters working in the province to create a local demand, operations closed in April.

Discovery and development in British Columbia.

The following notes regarding operations at Redonda Island are taken from the Report of the Minister of Mines for British Columbia:

"The mines on Redonda Island also furnished 900 tons of ore, which were shipped by steamer to Portland, Oregon.

"This property, represented by Messrs. De Wolf & Co., of Vancouver, comprises one hundred acres, situated on the north shore of Redonda Island, which lies 100 miles north of the city of Vancouver. The island is of granite formation. Of the two veins running north-east and south-west, No. 1 vein has been worked at a point some six hundred feet above high-water mark, offering facilities for loading the ore direct into a vessel by a chute. This vein shows a solid face of ore over forty feet wide, the whole of which is estimated to run sixty per cent met. iron. No. 2 vein is undeveloped, and shows thirty-six feet of solid ore."

The following analysis made in the Laboratory of the Survey proves the ore to be of good quality †:—

Metallic iron	65·896
Sulphur	·015
Phosphorus	*Nil.*
Titanic acid	*Nil.*

* Annual Report of the Geological Survey for 1877-78, p. 21 C.

†Summarised from a complete analysis made in the Laboratory of the Survey For further details see Geological Survey Reports, vol. VI. (N.S.) p. 35 R.

IRON.

PIG IRON AND STEEL.

Pig iron and teel.

Of the 125,602 tons of ore mentioned previously as the product of the mines of the Dominion, 124,053 tons were consumed in the country in the manufacture of pig iron as shown in table 3 following.

IRON.

TABLE 3.

PIG IRON PRODUCTION: CONSUMPTION OF ORE, FUEL, ETC.

Materials made and used.	1893.		1894.	
	Quantity.	Value.	Quantity.	Value.
Pig iron made.......... Tons.	55,947	$790,283	49,967	$646,447
Iron ore consumed. .... "	124,053	296,979	108,871	223,861
Fuel consumed: Charcoal. Bush.	1,302,720	90,976	1,173,970	53,958
Fuel consumed: Coke.... Tons.	58,711	163,849	52,373	142,303
Fuel consumed: Coal.... "	6,621	13,539	7,653	14,571
Flux consumed .... "	27,797	27,519	35,101	34,347

There were five furnaces in blast during 1893, three in Nova Scotia and two in Quebec by the following companies. Of these, three used charcoal and two coke and coal for fuel.

The New Glasgow Iron, Coal and Railway Co., Ltd..	In Nova Scotia.
The Londonderry Iron Company..................	In Nova Scotia.
The Pictou Charcoal Iron Company............. .	In Nova Scotia.
The Canada Iron Furnace Company..............	In Quebec.
Messrs. John McDougall & Co..................	In Quebec.

The Canada Iron Furnace Company did not run full blast this year owing to scarcity of labour in the woods for securing a supply of fuel. This difficulty was subsequently obviated so that there should be no limitation of output on this account next year.

The returns received show that altogether this industry in the two provinces gave employment to some 1,735 men. This number, however, included, besides the force employed around the furnace, all others also engaged in mining the ore, quarrying the limestone for flux and in cutting wood and burning charcoal where that is used as fuel.

EXPORTS AND IMPORTS.

Exports and imports.

Data regarding exports and imports of iron and steel goods will be found in the following tables. No. 4 gives the exports of iron and steel goods, 5, 6, 7 and 8 relate to imports of similar goods of which the value is based chiefly upon the amount of iron they contain rather than upon their highly manufactured condition.

IRON.

Iron.

Exports and imports.

TABLE 4.

EXPORTS OF IRON AND STEEL GOODS, THE PRODUCE OF CANADA, 1893.

Province.	Scrap Iron.	Iron Stoves.	Iron Castings.	Iron, all other and hard-ware.	Steel and manufactures of.	Totals.
	$	$	$	$	$	$
Ontario	1,062	531	5,701	8,749	17,797	33,840
Quebec	3,145	372	3,653	99,844	15,440	122,454
Nova Scotia	....	845	2,196	16,506	32,083	51,630
New Brunswick	....	150	....	3,582	....	3,732
Manitoba	....	249	3	69	856	1,177
British Columbia	....	168	108	1,195	264	1,735
North-west Territory	....	....	....	68	....	68
Totals	4,207	2,315	11,661	130,013	66,440	214,636

IRON.

TABLE 4*a*.

EXPORTS OF IRON AND STEEL GOODS, THE PRODUCE OF CANADA, 1894.

Province.	Scrap Iron.	Iron Stoves.	Iron Castings.	Iron, all other and hard-ware.	Steel and manufactures of.	Totals.
	$	$	$	$	$	$
Ontario	833	957	7,542	12,110	14,459	35,901
Quebec	3,569	662	5,746	83,115	9,002	102,094
Nova Scotia	10	2,056	1,056	11,567	10,412	25,101
New Brunswick	626	....	....	2,142	....	2,768
Prince Edward Island	....	....	....	40	....	40
Manitoba	....	47	....	51	349	447
North-west Territory	203	....	....	14	....	217
British Columbia	....	15	8	579	13	615
Totals	5,241	3,737	14,352	109,618	34,235	167,183

Iron.

Exports and imports.

Iron.

Table 5.

Imports of Iron, Pig, Scrap, etc.

Fiscal Year	Pig Iron.		Charcoal Pig Iron.		Old and Scrap Iron.		Wrought Scrap and Scrap Steel.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
		$		$		$		$
1880	23,159	(a) 371,956	....	....	928	14,042	....	....
1881	43,630	(a) 715,997	....	....	584	8,807	....	....
1882	56,594	811,221	6,837	211,791	1,327	20,406	....	....
1883	75,295	1,085,755	2,198	58,994	709	7,776	....	....
1884	49,291	653,708	2,893	66,602	3,136	44,223	....	....
1885	42,279	545,426	1,119	27,333	3,552	46,275	....	....
1886	42,463	528,483	3,185	60,086	10,151	158,100	....	....
1887	46,295	554,388	3,919	77,420	17,612	220,167	(b) 79	1,086
	Pig Iron, &c. (c)							
	Tons.	Value.						
		$						
1888	48,973	648,012	....	....	....	....	23,293	297,496
1889	72,115	864,752	....	....	....	....	26,794	335,090
1890	87,613	1,148,078	....	....	....	....	47,846	678,574
1891	81,317	1,085,929	....	....	....	....	43,967	652,842
1892	68,918	886,485	....	....	....	....	32,627	433,695
	Pig Iron.		Charcoal Pig Iron.		Cast Scrap Iron			
	Tons.	Value.	Tons.	Value.	Tons.	Value.		
		$		$		$		
1893	56,849	682,209	5,944	84,358	729	9,317	45,459	574,809
1894	42,376	483,787	2.906	34,968	78	771	30,850	369,682

(a) Comprises pig iron of all kinds.

(b) From 13th May only.

(c) These figures appear in Customs reports under heading "Iron in pigs, iron kentledge and cast scrap iron."

Iron.

Table 6.

Imports of Ferro-manganese, etc.*

Fiscal Year	Tons.	Value
1887	123	$ 1,435
1888	1,883	29,812
1889	5,868	72,108
1890	696	18,895
1891	2,707	40,711

*These amounts include:—ferro-manganese, ferro-silicon, spiegel, steel bloom ends, and crop ends of steel rails, for the manufacture of iron or steel.

IRON.

Exports and imports.

IRON.

TABLE 7.

IMPORTS: IRON IN SLABS, BLOOMS, LOOPS AND PUDDLED BARS, ETC.

Fiscal Year.	Cwt.	Value.
1880	195,572	$244,601
1881	111 666	111,374
1882	203,888	222,056
1883	258,639	269,818
1884	252,310	264,045
1885	312 329	287,734
1886	273,316	248,461
1887	522,853	421,598
1888	110,279	93,377
1889	80,383	67,181
1890	15,041	45,923
1891	41,567	38,931
1892	64,397	56,186
1893	65,269	58,533
1894	50,891	45,018

IRON.

TABLE 8.

IMPORTS OF IRON AND STEEL GOODS.

Fiscal Year.	Value.
1880	$6,620,260
1881	8,484,175
1882	8,578,685
1883	8,613,739
1884	6,143,870
1885	4,606,193
1886	4,698,882
1887	6,084,704
1888	5,147,111
1889	7,108,052
1890	7,260,845
1891	9,188,502
1892	9,509,489
1893	7,580,999
1894	5,917,921

LEAD.

Lead.

Production.

During 1893 the lead contents of the ores mined and shipped amounted to 2,135,023 pounds, which at the average price of the metal for the year, viz., 3·70 cents, would be worth $78,996. Compared with the preceding year, these figures show an increase of over twenty per cent in quantity.

The production for a number of years is as follows :—

1890...........	113,000 lbs.	valued at	$ 5,805
1891...........	588,665	"	25,607
1892...........	1,768,420	"	72,505
1893...........	2,135,023	"	78,996

Beyond about 4,000 lbs. to be credited to Ontario, the production given above represents the calculated lead contents of the silver-bearing ores shipped from the various camps in Kootenay and Yale districts in British Columbia, as far as could be ascertained.

The production for 1894 was 5,703,222 pounds valued at $185,355, the increase as compared with 1893, being entirely due to the further development of the mining of silver-lead ores in British Columbia.

Exports and imports.

EXPORTS AND IMPORTS.

Lead.

Table 1.

Imports of Lead.

Fiscal Year.	Old, Scrap and Pig.		Bars, Blocks, Sheets.		Total.	
	Cwt.	Value.	Cwt.	Value.	Cwt.	Value.
1880	....	....	....	....	30,298	$124,117
1881...........	16,236	$ 56,919	18,222	$70,744	34,458	127,663
1882...........	36,655	120,870	10,540	35,728	47,195	156,598
1883...........	48,780	148,759	8,591	28,785	57,371	177,544
1884...........	39,409	103,413	9,704	28,458	49,113	131,871
1885	36,106	87,038	9,362	24,396	45,468	111.434
1886...........	39,945	110,947	9,793	28,948	49,738	139,895
1887	61,160	173,477	14,153	41,746	75,313	215,223
1888...........	68,678	196,845	14,957	45,900	83,635	242,745
1889	74,223	213,132	14,173	43,482	88,396	256,614
1890...........	101,197	283,096	19,083	59,484	120,280	342,580
1891...........	86,382	243,033	15,646	48,220	102,028	291,253
1892...........	97,375	254,384	11,299	32,368	108,674	286,752
1893...........	94,485	215,521	12,403	32,286	106,888	247,807
1894...........	70,223	149,440	8,486	20,451	78,709	169,891

LEAD.

TABLE 2.

IMPORTS OF LEAD MANUFACTURES.

LEAD.

Exports and imports.

Fiscal Year.	Value.
1880	$15,400
1881	22,629
1882	17,282
1883	25,556
1884	31,361
1885	36,340
1886	33,078
1887	19,140
1888	18,816
1889	16,315
1890	25,600
1891	23,893
1892	22,636
1893	33,783
1894	29,361

DISCOVERY AND DEVELOPMENT.

Discovery and development.

QUEBEC.

There was very little done in this province during the year. The Lake Temiscamingue mine remained closed down, as it has been for some years. The Lawn mine on lots 10 and 11, Range IV., Calumet Island, was operated on a small scale by three men for about six months. Several openings were made and a trial shipment of about fourteen tons and a half of ore sent to Swansea, England, which it is said gave thirteen per cent of lead with 38·9 per cent of zinc and eleven ounces of silver to the ton. The cost of transport to Swansea is stated to have been from six to seven dollars per ton.

BRITISH COLUMBIA.

There is continued activity in the districts of the province producing the silver bearing ores which are the source of the lead. As full details regarding these mining operations are given later on in the article on Precious Metals, nothing further need be said here.

MANGANESE.

MANGANESE.

Production.

The figures of production of this mineral for 1893, show an increase of about 85 per cent in the quantity over those of 1892. Owing, however, to the lower average price realized, the increase in the total values is only about forty-two per cent.

MANGANESE, Production.

During past years the production was as follows :—

1886	1,789	tons valued at	$41,499
1887	1,245	"	43,658
1888	1,801	"	47,944
1889	1,455	"	32,737
1890	1,328	"	32,550
1891	255	"	6,694
1892	115	"	10,250
1893	213	"	14,578

The production for 1894 is 74 tons valued at $4,180.

Exports and imports.

EXPORTS AND IMPORTS.

Tables 1 and 2, following, give the figures of exports and imports. The exports made were all to the United States.

MANGANESE.

TABLE 1.

EXPORTS OF MANGANESE ORE.

YEARS.	NOVA SCOTIA.		NEW BRUNSWICK.		TOTAL.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1873	....	....	1,031	$20,192	1,031	$20,192
1874	6	$ 12	776	16,961	782	16,973
1875	....	200	194	5,314	203	5,514
1876	21	723	391	7,316	412	8,039
1877	106	3,699	785	12,210	891	15,909
1878	106	4,889	520	5,971	626	10,860
1879	154	7,420	1,732	20,016	1,886	27,436
1880	79	3,090	2,100	31,707	2,179	34,797
1881	200	18,022	1,504	22,532	1,704	40,554
1882	123	11,520	771	14,227	894	25,747
1883	313	8,635	1,013	16,708	1,326	25,343
1884	134	1,054	469	9,035	603	20,089
1885	77	5,054	1,607	29,595	1,684	34,649
1886	(*a*) 441	854	1,377	27,484	(*a*)1,818	58,338
1887	578	14,240	837	20,562	1,415	34,802
1888	87	5,759	1,094	16,073	1,181	21,832
1889	59	3,024	1,377	26,326	1,436	29,350
1890	177	2,583	1,729	34,248	1,906	36,831
1891	22	563	233	6,131	255	6,694
1892	84	6,180	59	2,025	143	8,205
1893	123	12,409	10	112	133	12,521
1894	11	720	45	2,400	56	3,120

(*a*) 250 tons from Cornwallis should more correctly be classed under the heading of mineral pigments.

MANGANESE.

Exports and imports.

MANGANESE.
TABLE 2.
IMPORTS: OXIDE OF MANGANESE.

Fiscal Year.	Pounds.	Value.
1884	3,989	$ 258
1885	36,778	1,794
1886	44,967	1,753
1887	59,655	2,933
1888	65,014	3,022
1889	52,241	2,182
1890	67,452	3,192
1891	92,087	3,743
1892	76,097	3,530
1893	94,116	3,696
1894	101,863	4,522

Discovery and development.

DISCOVERY AND DEVELOPMENT.

No new discoveries of any importance were reported in this industry. As in former years, the deposits of Nova Scotia and New Brunswick were the only ones worked.

In the two provinces, about fifty men were employed by some five operators, most of whom worked only a few months out of the year. It is thus seen that the work is very desultory, and the mines were in some cases sublet to tributors by the companies owning the mines.

A description of the mode of occurrence of these deposits having been given in previous issues, need not be repeated here. Mr. Fletcher, in summarizing the results of his work in the eastern part of Hants county, Nova Scotia, gives notes of sundry of the numerous manganese deposits of that district in the Summary Report of the Geological Survey for 1893, pp. 40 to 43.

MICA.

MICA.

Production.

The yearly values of the marketed production of this mineral for several years is given below, viz.:—

1886	$ 29,008
1887	29,816
1888	30,207
1889	28,718
1890	68,074
1891	71,510
1892	104,745
1893	75,719
1894	45,581

Mica.

Production.

The industry continues to be carried on much in the same way as in the past, for, outside of a few larger operators, it is mined in small lots and in an irregular manner, small gangs of men being employed wherever there would seem promise of obtaining large crystals of the mineral, the resulting product being sold to the buying agents of the consuming electrical manufacturers, or to the larger operators.

Owing to the difficulty thus arising of obtaining direct returns, the above figures of production are based upon the export, with the addition of the amounts of Canadian mica known to be used by the home manufacturers.

Exports and imports.

EXPORTS AND IMPORTS.

The exports of this mineral for the past few years are as follows:—

1887	$ 3,480
1888	23,563
1889	30,597
1890	22,468
1891	37,590
1892	86,562
1893	70,081
1894	38,971

The figures for 1893 include ground mica to the value of $932.

Discovery and development.

DISCOVERY AND DEVELOPMENT.

Quebec.

The history of the industry in this province during the year 1893, presents no very startling features. Most of the larger operators of 1892 continued to produce, and the usual number of new finds were reported.

Dr. Ells in the course of his work for the Geological Survey, visited many localities where mica occurs, or was said to occur, and his summary report* of his season's work makes mention as follows: "Mica occurs in several places, among which may be mentioned lot 13, range II., Denholm. The deposit has not been developed, but the specimens from the surface are clear and of good colour."—"Near the end of the road east from Paugan Falls, about four miles from the river, a deposit of mica has recently been opened at Wilson's, which has yielded some good crystals and several tons of mica have been extracted." Speaking of Lake Dumont district, north of Clapham

*Summary Report of the Geological Survey Department for 1893, pp. 29 & 30.

township in Pontiac county, he says:—"Reported outcrops of mica and phosphate at several points were examined, but the quantity seen in every case was insignificant." Mica.

"Mica was found near the road along the west side of the Gatineau on lot 36, range I., Bouchette, where several openings have been made in a pyroxene dyke which cuts red and gray gneiss, and on lots 14 and 15, range D of Wright, a mass of mica crystals occurs in a dyke of pyroxene with calcite. The quantity of mica crystals is here very great and some of them are of large size and good colour, but are injured by having, in the centre in many cases, small inclusions of calcite. Similar deposits are found on the west side of Bittobee Lake, south of the Gatineau, near the line between Wright and Northfield, though the quantity of crystals is here much less and they are of smaller size. Discovery and development.

"In the township of Aylwin, another deposit of mica (muscovite) occurs, about half a mile north of Venosta station. It occurs here in a dyke or vein of felspar and quartz, cutting grayish garnetiferous gneiss, and some excellent crystals were at one time obtained. The mica, however, appeared to terminate in the place where worked, which was near the centre of the dyke, and the mine was in consequence abandoned.

"In the township of Hincks, on lot 22, range II., on land owned by J. Quinn, of Aylwin, mica (phlogopite) occurs in large smooth crystals, in a pyroxene dyke cut by a cross dyke of felspar. The mica is dark amber-coloured, but the size of the crystals and the freedom from inclusions and flaws enables plates of extra size to be easily obtained."

In the same publication Mr. Giroux gives the result of a visit to a mica occurrence at Lac à Baude in the rear of Champlain county, which he thus describes: "At the northern end of this lake is a mass of quartz and felspar rock with crystals of mica.......... At the western end of the above mentioned mass is a vein five feet wide of quartz and felspar rock, holding large crystals of biotite, and at the contact of this vein with the gneiss the quartz is almost black."

Mr. Brumell, while engaged in field work, visited several deposits in Hastings county, but found that nothing whatever had been done beyond locating the various properties, on none of which were the deposits of very great commercial value. The mica deposits visited were at L'Amable in Dungannon township, and north of Bird Creek in Monteagle.

Mineral pigments.

MINERAL PIGMENTS.

Of the various mineral substances coming under the above heading, there is no production to report other than that given below for ochres.

Ochres.

Ochres.—The increase in the production of ochres amounts to nearly 175 per cent on the quantity returned for 1892, and about 205 per cent in the values. All but about ten per cent was produced in the province of Quebec, small amounts only having been mined in the provinces of Nova Scotia and Ontario.

The figures given below enable comparison to be made with previous years:

1887...............	385 tons, valued, at		$2,233
1888...............	397	"	7,900
1889...............	794	"	15,280
1890...............	275	"	5,125
1891...............	900	"	17,750
1892...............	390	"	5,800
1893...............	1,070	"	17,710

The production during 1894 was 611 tons, valued at $8,690.

Barytes.

Barytes.—The McKellar's Island deposit was not worked, nor were any others of the numerous veins carrying this mineral in various parts of the Dominion.

During 1894 the shipments of baryta were 1,080 tons, valued at $2,830.

Exports and imports.

EXPORTS AND IMPORTS.

The customs returns show exports of ochre from Quebec to the United States, with a small amount to Newfoundland, to the amount of 150,150 lbs. valued at $819.

The imports of the various substances coming under this heading, will be found in the following tables, Nos. 1. 2, and 3 :—

Mineral pigments.

Exports and imports.

MINERAL PIGMENTS.

TABLE 1.

IMPORTS OF OCHRES.

Fiscal Year.	Pounds.	Value.
1880	571,454	$ 6,544
1881	677,115	8,972
1882	731,526	8,202
1883	898,376	10,375
1884	533,416	6,398
1885	1,119,177	12,782
1886	1,100,243	12,267
1887	1,460,128	17,067
1888	1,725,460	17,664
1889	1,342,783	12,994
1890	1,394,811	14,066
1891	1,528,696	20,550
1892	1,708,645	22,908
1893	1,968,645	23,134
1894	1,358,326	18,951

MINERAL PIGMENTS.

TABLE 2.

IMPORTS OF BARYTA.

Fiscal Year.	Cwt.	Value.
1880	2,230	$1,525
1881	3,740	1,011
1882	497	303
1883	....	185
1884	....	229
1885	7	14
1886	....	62
1887	379	676
1888	236	214
1889	1,332	987
1890	1,322	978

Mineral pigments.

Exports and imports.

MINERAL PIGMENTS.

TABLE 3.

IMPORTS OF LITHARGE.

Fiscal Year.	Cwt.	Value.
1880	3,041	$14,334
1881	6,126	22,129
1882	4,900	16,651
1883	1,532	6,173
1884	5,235	18,132
1885	4,990	16,156
1886	4,928	16,003
1887	6,397	21,865
1888	7,010	23,808
1889	8,089	31,082
1890	9,453	31,401
1891	7,979	27,613
1892	10,384	34,343
1893	7,685	24,401
1894	38,547	28,685

Mineral water.

MINERAL WATER.

Production.

The production of mineral water during the year 1893 amounted to 725,096 gallons, having a spot value of $108,347 ; showing an increase, compared with 1892, of 84,716 gallons, and in value of $32,999.

The production by provinces was as follows :—

Ontario	421,136 gallons,	valued at	$24,458
Quebec	251,660 "	"	57,839
New Brunswick	39,250 "	"	14,800
Nova Scotia	13,050 "	"	7,250

The following table shows the annual production since 1888 :—

1888	124,850 gallons	$ 11,456
1889	424,600 "	37,360
1890	561,165 "	66,031
1891	427,485 "	54,268
1892	640,380 "	75,348
1893	725,096 "	108,347
1894	767,460 "	110,040

It will be seen on reference to the above, that there has been a steady increase in production, which has not, however, tended to lessen the imports, a fact made evident by reference to the table of imports given below.

DISCOVERY AND DEVELOPMENT.

MINERAL WATER.

Discovery and development.

Large quantities of domestic natural mineral water are annually aerated bottled and go upon the market under the various names of "St. Leon," "Eudo," "Obico," "Havelock," "Spa," "Caledonia," and others too numerous to mention.

The following list comprises the principal and largest producers during the year 1893:—

Wilmot Spa Springs Co	Middleton, N.S.
Havelock Mineral Springs Co	Petitcodiac, N.B.
J. R. Smith, "Apohaqui Water"	St. John, N.B.
St. Leon Mineral Water Co	St. Leon Springs, Que.
J. A. Harte, "Richelieu Water"	Montreal, Que.
" "St. Genevieve"	" "
Jos. Domphousse, "Divina"	" "
Grand Hotel Co., "Caledonia"	Caledonia Springs, Ont.
F. O. Ring, "Victoria Sulphur Water"	Ottawa, Ont.
Wm. Borthwick	" "
W.K. Kains, "Georgian Water"	Treadwell, Ont.
J. Boyd & Son	Eastmans Springs, Ont.
R. A. Smith, "Ancaster Water"	Toronto, Ont.
Eudo Mineral Water Co	" "
Saugeen Natural Mineral Water Co	Southampton, Ont.
W. J. Anderson, M.D., "Winchester Springs"	Smith's Fall's, Ont.
Chris. Kress, "Preston Water"	Preston, Ont.
Obico Mineral Water Co	Toronto, Ont.

The natural mineral water of Harrison Hot Springs, in British Columbia, is now, it is believed, being bottled and sold by Messrs. Blackwood Bros., of Winnipeg.

The industry as a whole is assuming considerable proportions, and from information at hand it is expected that several other varieties will shortly be placed on the market, thus warranting the belief that Canada will soon be an exporter of natural mineral waters, of which she has within her boundaries a great many varieties.

Mineral water.

The following table illustrates the imports during 1894, and previous years ; no exports are reported.

Exports and imports.

MINERAL WATERS.

TABLE 1.

IMPORTS.

Fiscal Year.	Value.
1880	$15,721
1881	17,913
1882	27,909
1883	28,130
1884	27,879
1885	32,674
1886	22,142
1887	33,314
1888	38,046
1889	30,343
1890	40,802
1891	41,797
1892	55,763
1893	57,953
1884	49,546

Miscellaneous.

MISCELLANEOUS.

Under this heading are included a number of mineral substances which are only produced irregularly or in a small way in Canada, and to which therefore only reference need be made.

Antimony.

Antimony.—As will be seen, this has been a failing industry for some years, and for the past three years there is no production to report. The production was as follows :—

1887	584	tons,	valued at	$10,860
1888	345	"	"	3,696
1889	55	"	"	1,100
1890	26½	"	"	625
1891	10	"	"	60
1892	nil	"	"	nil
1893	nil	"	"	nil

There is also nothing to report for 1894.

Table No. 1 gives the exports up to 1891, since which date there is nothing to report. Table No. 2 explains itself.

MISCELLANEOUS.

TABLE 1.

EXPORTS OF ANTIMONY ORES.

MISCELLANEOUS.

Antimony.

Year.	Tons.	Value.	Year.	Tons.	Value.
1880	40	$ 1,948	1887	229	$9,720
1881	34	3,308	1888	352½	6,894
1882	323	11,673	1889	30	695
1883	165	4,200	1890	38	1,000
1884	483	17,875	1891	3½	60
1885	758	36,250	1892	....	....
1886	665	31,490	1893	....	....

MISCELLANEOUS.

TABLE 2.

IMPORTS OF ANTIMONY.

Fiscal Year.	Pounds.	Value.
1880	42,247	$ 5,903
1881	....	7,060
1882	183,597	15,044
1883	105,346	10,355
1884	445,600	15,564
1885	82, 12	8,182
1886	89,787	6,951
1887	87,827	7,122
1888	120,125	12,242
1889	119,034	11,206
1890	117,066	17,439
1891	114,084	17,483
1892	180,308	17,680
1893	181,823	14,771
1894	139,571	12,249

Arsenic.—The production of white arsenic by refining the crude material of the condensing chambers of the old gold mines at Deloro, Hastings county, Ontario, has been suspended and for 1892 and 1893 there is nothing to report. Arsenic.

Miscellaneous.

Arsenic.

The production during past years was as follows :

1885	440 tons,	valued at	$17,600
1886	120 "	"	5,460
1887	30 "	"	1,200
1888	30 "	"	1,200
1889	Nil "	"	Nil
1890	25 "	"	1,500
1891	20 "	"	1,000

During 1894 the production was 7 tons, valued at $420.

Table No. 3 gives the home market for white arsenic for a number of years.

Miscellaneous.

Table 3.

Imports of Arsenic.

Fiscal Year.	Pounds.	Value.
1880	18,197	$ 576
1881	31,417	1,070
1882	138,920	3,962
1883	51,953	1,812
1884	19,337	773
1885	49,080	1,566
1886	30,181	961
1887	32,436	1,116
1888	27,510	1,016
1889	69,269	2,434
1890	138,509	4,474
1891	115,248	4,027
1892	302,958	9,365
1893	447,079	12,907
1894	292,505	10,018

Felspar.

Felspar.—There was an encouraging increase in the production of this mineral during 1893 over that for 1892, but no production is reported in 1894. The figures are as follows :

1890	700 tons,	valued at	$3,500
1891	685 "	"	3,425
1892	175 "	"	525
1893	575 "	"	4,525

A number of deposits of felspar, of greater or less extent, are known to exist in Ontario and Quebec, but most of them are not available at present owing to transportation difficulties. There were fifty tons exported in 1893. No figures of imports are available, nor is it

likely that any of the mineral has been brought in, the local demand being easily satisfied from the available Canadian mines. MISCELLANEOUS.

Fireclay.—The returns received of the production of fireclay since 1889 give the following result : Fireclay.

1889..............	400 tons, valued at	$4,800
1890..............	Not reported.	
1891..............	250 tons, valued at	750
1892..............	1,991 " "	4,467
1893..............	540 " "	700

This was produced in Nova Scotia and Quebec. In the former province it is obtained in connection with the coal mining carried on there.

During 1894, the production was 539 tons, valued at $2,167, the greater part of which is to be credited to New Brunswick and British Columbia.

Lithographic Stone.—During the year 1893 renewed interest was awakened in the deposits of this material which have been known to occur in the vicinity of Marmora in Hastings county, Ontario. Beyond samples, no shipments were made from the quarries. The work done consisted wholly in opening the quarry and the erection of a mill for the preparation of the stones. By direct returns to this office for 1894, the production is reported to have been 180 tons, valued at $30,000.* Lithographic stone.

Mercury.—Little was done in respect to mercury during the year. At the Rosebush group of claims at Savona, British Columbia, work was suspended during the summer pending negotiations for the sale of the property. Reports are to hand giving the amount of ore on the dump as almost five tons, running about seven to eight per cent. This deposit was noticed in the report for 1892, and since the start but little work has been done that would yield ore. Mercury.

The amount of mercury used in Canada is illustrated by the accompanying table of imports.

* It would seem from later information that this represents what was mined and that but a very small proportion of this amount was marketed, only test lots having been shipped away.

MISCELLANEOUS.

Mercury.

MISCELLANEOUS.

TABLE 4.

IMPORTS OF MERCURY.

Fiscal Year.	Pounds.	Value.
1882.	2,443	$ 965
1883.	7,410	2,991
1884.	5,848	2,441
1885.	14,490	4,781
1886.	13,316	7,142
1887.	18,409	10,618
1888.	27,951	14,943
1889.	22,931	11,844
1890.	15,912	7,677
1891.	29,775	20,223
1892.	30,936	15,038
1893.	50,711	22,998
1894.	36,914	14,483

Moulding sand.

Moulding Sand.—As far as could be ascertained, the production of moulding sand during 1893 was as follows :—

Ontario	2,950 tons,	valued at	$5,900
Nova Scotia	1,780	"	3,186
	4,370		$9,086

The production of previous years, as under, was altogether that of Nova Scotia :—

1887	160 tons,	valued at	$800
1888	169	"	845
1889	170	"	850
1890	320	"	1,410
1891	230	"	1,000
1892	345	"	1,380

During 1894 the production is reported as 6,214 tons, valued at $12,428, the amount being about equally divided between Nova Scotia and Ontario.

Platinum.

Platinum.—As in past years the production of platinum is altogether that of British Columbia. It is obtained from the gravels of the stream beds of the Similikameen division of Yale district. The figures of production since 1887 are given below :—

MISCELLANEOUS.

Platinum.

1887	$ 5,600
1888	6,000
1889	3,500
1890	4,500
1891	10,000
1892	3,500
1893	1,800
1894	950

MISCELLANEOUS.

TABLE 5.

IMPORTS OF PLATINUM.

Fiscal Year.	Value.
1883	$ 113
1884	576
1885	792
1886	1,154
1887	1,422
1888	13,475
1889	3,167
1890	5,215
1891	4,055
1892	1,952
1893	14,082
1894	7,151

Precious stones.

Precious Stones.—Under this heading are included all cut and polished Canadian gem stones and certain ornamental ones such as agate, perthite, peristerite, jasper and jasper conglomerate. The cut gems include asteriated quartz, sodalite, garnet, labradorite, etc.

The production for the year 1893 was valued at about $1,500. The production for 1894 is about the same as the previous year.

There were imported $115,086 worth during the fiscal year ending 30th June, 1893. Diamonds, however, are included under this heading in the customs entries.

Quartz.

Quartz.—But a small quantity of quartz was produced during 1893, amounting to one hundred tons valued at $500. This was mined on the north shore of the St. Lawrence near Quebec and used in making sidewalks and floors.

MISCELLANEOUS.

Soapstone.

Soapstone.—There is a large falling off in the production since 1892 as will be seen by an inspection of the following figures :

1886	50 tons,	valued at	$ 400
1887	100	"	800
1888	140	"	280
1889	195	"	1,170
1890	917	"	1,239
1891	Nil	"	Nil
1892	1,374	"	6,240
1893	717	"	1,920

The material mined is used in the manufacture of fireproof roofing cement.

During 1894 the production is reported as 916 tons, valued at $1,640.

Tin.

Tin.—No tin has ever been produced in Canada, nor are any deposits of its ores, of economic importance, known to exist.

The following table is, however, given as illustrative to a certain extent of the local market for tin and tinned goods.

MISCELLANEOUS.

TABLE 6.

IMPORTS OF TIN AND TINWARE.

Fiscal Year.	Value.
1880	$ 281,880
1881	413,924
1882	790,285
1883	1,274,150
1884	1,018,493
1885	1,060,883
1886	1,117,368
1887	1,187,312
1888	1,164,273
1889	1,243,794
1890	1,289,756
1891	1,206,918
1892	1,594,205
1893	1,242,994
1894	1,310,389

Whiting and chalk.

Whiting and Chalk.—As neither of these mineral substances were produced in Canada in 1893, there is no information to be given other than that to be found in the accompanying tables of imports.

MISCELLANEOUS.

Whiting and chalk.

MISCELLANEOUS.

TABLE 7.

IMPORTS OF WHITING.

Fiscal Year.	Cwt.	Value.
1880	84,115	$26,092
1881	47,480	16,637
1882	36,270	16,318
1883	76,012	29,334
1884	76,268	28,230
1885	67,441	23,492
1886	65,124	25,533
1887	47,246	15,191
1888	76,619	20,508
1889	84,658	22,735
1890	96,243	27,471
1891	84,679	27,504
1892	102,985	26,867
1893	88,835	25,563
1894	103,633	26,649

MISCELLANEOUS.

TABLE 8.

IMPORTS OF CHALK.

Fiscal Year.	Value.
1880	$2,117
1881	2,768
1882	2,882
1883	5,067
1884	2,589
1885	8,003
1886	6,583
1887	5,635
1888	5,865
1889	5,336
1890	7,221
1891	8,193
1892	9,558
1893	9,966
1894	11,308

Zinc.

Zinc.—As a result of the exploratory work begun in 1892 at the Lawn Mine in Calumet Island, Pontiac County, Quebec, and alluded to in last year's issue, there is a small amount of zinc to report as production for 1893. This represents the zinc contents of a trial shipment of ore sent to England in the early part of the year, and amounted to 11,763 pounds, which at the market price of the metal would be worth $470.

MISCELLANEOUS.

The following tables speak for themselves.

MISCELLANEOUS.

TABLE 9.

Imports of zinc.

IMPORTS OF ZINC IN BLOCKS, PIGS AND SHEETS.

Fiscal Year.	Cwt.	Value.
1880	13,805	$67,881
1881	20,920	94,015
1882	15,021	76,631
1883	22,765	94,799
1884	18,945	77,373
1885	20,954	70,598
1886	23,146	85,599
1887	26,142	98,557
1888	16,407	65,827
1889	19,782	83,935
1890	18,236	92,530
1891	17,984	105,023
1892	21,881	127,302
1893	26,446	124,360
1894	20,774	90,680

MISCELLANEOUS.

TABLE 10.

IMPORTS OF SPELTER.

Fiscal Year.	Cwt.	Value.
1880	1,073	$ 5,310
1881	2,904	12,276
1882	1,654	7,779
1883	1,274	5,196
1884	2,239	10,417
1885	3,325	10,875
1886	5,432	18,238
1887	6,908	25,007
1888	7,772	29,762
1889	8,750	37,403
1890	14,570	71,122
1891	6,249	31,459
1892	13,909	62,550
1893	10,721	49,822
1894	8,423	35,615

MISCELLANEOUS.

MISCELLANEOUS.

TABLE 11.

IMPORTS OF ZINC, MANUFACTURES OF.

Imports of zinc.

Fiscal Year.	Value.
1880	$ 8,327
1881	20,178
1882	15,526
1883	22,599
1884	11,952
1885	9,459
1886	7,345
1887	6,561
1888	7,402
1889	7,233
1890	6,472
1891	7,178
1892	7,563
1893	7,464
1894	6,193

NATURAL GAS.

NATURAL GAS

By H. P. H. BRUMELL, F. G. S. A.

Production.

The value of natural gas marketed during 1893 shows a very marked increase over that of the previous year, being according to direct returns, $366,233, whilst the value for the year 1892 was only about $150,000. The production was practically altogether that of Ontario, a well at Medicine Hat, N.W.T., affording but a small quantity of gas for local use and the large increase shown over the output for 1892 is mainly due to the increased business of the companies operating in Welland county.

According to the report of the Bureau of Mines of Ontario for 1893, the total number of producing wells was 107, while for the transmission of natural gas there were 117 miles of pipe lines and the number of men employed in direct connection with the industry was fifty-nine. As in the past few years the largest market for the natural gas of Ontario was found in Buffalo, N.Y., into which there are two companies feeding gas from the Welland field. During the latter part of the year the Ontario Natural Gas Company of Essex county were busy laying mains from their wells in Gosfield south to Windsor, Walkerville and Sandwich, Ont., and Detroit, Mich.

The natural gas produced during 1894 was valued at $313,754.

Discovery and development.

York County.—The New Toronto Oil and Natural Gas Company continued operations into the beginning of the year 1893, and completed seven wells, in no case finding any large flow of gas. In three of the wells only was gas found and then in too small quantities to be of economic value. Fortunately no expense was entered into for the transmission of the gas, so that the company only lost the actual outlay for the sinking of their wells.

In one of the wells, sunk near Islington, a heavy flow of mineral water was struck which has since been put on the market as "Obico mineral water" and is bottled and sold by the Obico Mineral Water Company of Toronto.

Wentworth County.—The Hamilton Natural Gas and Mining Company finished their second well without finding gas in paying quantity. No. 1 well was sunk 1,950 feet, to the granite, above which was twelve feet of arkose beds. Trenton limestone was met with at 1,200 feet and a small show of gas was struck in this formation at 1830 feet. No. 2 well was sunk 1,597 feet, at which point the tools were lost, the boring being in Trenton limestone; a small flow of gas was found at 400 feet and at various points down to 500 feet.

Elgin County.—During the year 1893, a deep boring was begun in the town of St. Thomas by Mr. John Campbell; the boring in October reaching a depth of 1,640 feet, at which point a small flow of gas was found in the red Medina sandstone, insufficient however to be of commercial value. The surface deposits measured 282 feet, beneath which was found shale presumably of Hamilton age.

Surface Gas Wells of Elgin County.—Between St. Thomas and Chatham County, is a large area apparently entirely underlain by a practically impervious bed of clay, holding in reservoir large quantities of surface gas of good quality. In the neighbourhood of, and in the town of Ridgetown many wells have been sunk, from most of which are obtained heavy flows of gas. The record of a well sunk by Messrs. McMaster Bros. gave the following section:—

Surface soil, loam	6 feet.
Gravel, with water	23 "
Clay	57 "
Hardpan	2 "

Beneath this was found a fine-grained white sand holding the gas. The initial closed pressure at this well on a three and one half inch pipe was $14\frac{1}{2}$ pounds, and it is said to have afforded about 2,000,000 cubic feet of gas per day. Many other wells are said to have been

measured and to have produced 200,000 to 2,000,000 feet per day. As might be expected, the wells of this field have not so long a life as deep rock wells, but this difficulty seems to be offset by the fact that new wells can be sunk at a very slight cost.

NATURAL GAS. Discovery and development.

Many wells have been sunk throughout the district, the product being used locally. Full notes regarding many of these may be found in the First Report of the Bureau of Mines of Ontario.

Essex County.

In this county, the two operating companies continued to supply gas to Kingsville, Ruthven and Leamington and to scattered residences and buildings in the neighbourhood. The two companies are the Kingsville Natural Gas and Oil Company of Kingsville and the Ontario Natural Gas Company of Walkerville.

Kingsville Natural Gas and Oil Company.—This company have done no drilling since they opened their well No. 4 in December of 1891, but have extended and improved their system of mains and regulators. Their wells now being operated are as follows :—

No. 2—Road well,	with an initial flow of	4,184,900 c. ft.
No. 4—C. G. Fox	" "	2,231,000 "

Ontario Natural Gas Company.—This company carried on active drilling operations during the year and sunk five wells as follows :—

No. 8—Hy. Lypp's well	—Lot	5,	Con.	I.,	Gosfield S.
" 9—Whittle "	— "	7	"	II.	"
" 10—Wesley Wigle "	— "	7	"	I.	"
" 11—Ph. Fox "	— "	8	"	I.	"
" 12—W. J. Fox "	— "	9	"	I.	"

Well No. 8 was carried to a depth of 1,085 feet, the surface deposits measuring 55 feet. Casing was put down to a depth of 525 and a small show of gas was found at 700 feet, but as this was of no commercial value, the casing was drawn and the well abandoned.

Well No. 9 was sunk to a depth of 1,105 feet and at 800 feet a small show of gas was noted, not sufficient however to be of commercial value. The surface deposits measured 138 feet and casing was put down to a depth of 580 feet. A feature of this well, worthy of note, is that a small show of oil was met with at 1,035 feet.

Well No. 10 is one of the most successful wells of the field, the initial open flow being 5,877,500 cubic feet. The boring was carried to a depth of 980 feet, the surface deposits being 95 feet in thickness; casing was put down 530 feet. A small flow of gas was found at 685 feet, the main flow being from 900 to 955 feet.

NATURAL GAS. Discovery and development.

Well No. 11 was sunk to a depth of 1,004 feet, the surface deposits being 114 feet; casing 520 feet. Small flows of gas were met with at 685 and 890 feet while the large flow was struck at 965 feet, increasing in volume up to 990 feet. The initial open flow from this well was 5,700,000 cubic feet per day.

Well No. 12 was sunk late in the year to a depth of about 975 feet, the surface deposits being 123 feet, casing was carried to a depth of 510 and a small flow of gas was noted at 690 feet, the larger flow, —about 7,000,000 cubic feet—being found at 950 feet. At the time of my visit the well had not been measured, but the flow was thought to be equivalent to the above figures.

Welland County.

This county continued to be the largest producer of natural gas, most of the product being exported and utilized in the city of Buffalo, N. Y.

Provincial Natural Gas Company.—This company have during the year "brought in" several new wells which have been connected with their mains for the supply of Buffalo and the intermediate points, Erie, Victoria and Black Rock. They had at the end of 1893 finished sixty-nine wells, the greater proportion of which were still producing, though necessarily at a lower pressure than when first sunk.

A deep well was sunk on lot two, concession four of Willoughby township, reaching a depth of 3,030 feet, at which point granite was struck. The Trenton limestone was found at 2,340 feet, and proved to be entirely barren of gas. A small flow of gas was struck at 495 feet, in the Clinton, and again in the white sandstone of Medina age at from 615 to 637 feet.

Several of the new wells sunk during the year proved to be large producers, No. 63 producing 10,014,000 cubic feet when struck.

Before the close of the year the erection was begun by this company of a compressor plant near Sherk's Station, from whence to Buffalo they will lay a high-pressure main.

Erie County Natural Gas and Fuel Company.—This company continued to operate in this district, their wells being scattered through the territory drained by the Provincial Company. They have in the neighbourhood of thirty wells, most of which are producers. We have however been unable as yet to obtain from this company records of either capacity or boring.

Mutual Natural Gas Company.—This company did not undertake any boring operations during the year, but supplied the villages of

Port Colborne and the western part of Humberstone, as in the past, from their wells situated in these two places. NATURAL GAS.

Wells in vicinity of Humberstone.—That part of the village of Humberstone lying east of Welland canal, is largely supplied with gas from wells owned by Mr. A. Morningstar and G. A. Zimmerman, the former in the village and the latter about two miles further east. The well owned by Mr. Morningstar was sunk 830 feet and penetrated all the gas bearing strata of the Medina formation. Gas was struck at 665 feet and again in greater quantity at 798 feet; the gas at that point coming from the white Medina sandstone. Salt water was struck at about 513 feet, but was cased off, the casing reaching to the depth of 613 feet. At the time of my visit about sixty stoves, fifty-five lights, and several boilers and blacksmith's fires were being fed on the east side of the canal. Discovery and development.

Messrs. R. & J. Greenwood, also of Humberstone village, sunk a well on the west side of the canal and are now supplying about 100 stoves and many lights in Port Colborne in opposition to the Mutual Company of that place. The well reached a depth of 826 feet, was cased to 640 feet and affords gas from various points between 680 and 800 feet, the latter depth marking the base of the white sand of the Medina.

Bertie Natural Gas Company.—In the report of this division for last year, note is made of a well sunk by this company in Bertie village (Ridgeway). Since then the company has bored a second well in the northern part of the village, striking gas to the amount of 600,000 cubic feet, at a depth of 830 feet, the gas sand continuing to a depth of 842 feet. From these two wells the village now draws the greater part of its supply.

NICKEL.

NICKEL.

The figures for the production of this metal during 1893 and several previous years are as follows :— Production.

	Pounds of Nickel in matte, &c.				Total Value.
1890	1,435,742	valued at	65c.	per lb.	$ 933,232
1891	4,626,627	"	60c.	"	2,755,976
1892	2,413,717	"	58c.	"	1,399,956
1893	3,982,982	"	52c.	"	2,071,151

The figures as given above show an increase in 1893 over the production for 1892 of about 65 per cent in the total quantity, but, owing to a drop in price, of only 48 per cent in the gross value.

Nickel.
Production.

The valuations here adopted, conformably with that for other metallic products, is the average full value of the pure metal in the market.

The matte, &c., as shipped from the Sudbury Mines, must be valued at a much lower rate for the contained metals, so that the spot value of the product for 1893 would be about as follows :—

Nickel contents of matte, &c., 3,982,982 lbs. at 13c. per lb................	$518,567.66
Copper contents of matte, &c., 3,647,197 lbs. at 6c. per lb	218,831.82
Value of the matte as shipped.....	$737,399.48

The amount of matte shipped from the district was 9,425 tons which, at the above valuation, would have an average spot value of $78.23 per ton.

The average contents of the shipments as above, give 21·125 per cent of nickel and 19·345 per cent of copper. Although some of the shipments would range as low as 11 per cent nickel and 16 per cent copper, much of the matte would run as high as 40 per cent, or thereabouts, for each metal.

The production of nickel during 1894, as per returns received, was 4,907,430 lbs. valued at $1,870,958.

Discovery and development.

DISCOVERY AND DEVELOPMENT.

There is nothing very new to note about the operations in this industry during the year.

Reports of the discovery of some deposits of pyrrhotite in various parts of the country, came to hand through the specimens received by the Laboratory of the Survey for assay, particulars of which will be found in the report of that branch for 1893.* Of the analyses made, 26 specimens were from various points in Eastern Ontario ; one from Nova Scotia ; one from Quebec ; two from the region about Sudbury ; one from the N. shore of L. Superior, and one from the Rainy River district ; eight from British Columbia, and one from the N. W. Territories. With the exception of one from near Sudbury, Ontario, none ran over 0·25 per cent of nickel, whilst in many cases but a trace of that metal was found.

The productive work was confined to the operations of the following companies, descriptions of whose mode of operations have been given already in previous reports, viz. : The Canadian Copper Company, The

* Annual Report Geol. Surv. Can., vol. VI. (N.S.) pp. 37 R—46 R.

Dominion Mineral Company, Messrs. H. H. Vivian & Co. Work was carried on by the Drury Nickel Company at the Travers Mine, but no shipments were made, and no mining was done by them after February 1st, operations being confined to the completion of the works on the surface. When working both the mine and the smelter the company employed about 100 men. The plant consists of one Jenckes rectangular water-jacket cupola furnace of 60 tons capacity, with fixed fore-hearth and 12 tuyeres, six on each side, with two Baker blowers driven by a 50 horse-power engine to supply the cupolas, whilst the bessemerising plant is supplied by a vertical Fraser & Chalmers blower with 3 foot cylinder, the blast carrying about 16 lbs. pressure. There is also a coke shed 100 ft. by 120 ft., and pug mill and corn rolls for preparing the clay and quartz lining for the Manhé converters, with a very perfect system for elevating the furnace charges, &c. The bessemerised matte produced is said to run from 30 to 67 per cent of nickel. The depth attained up to the time of suspending the mining work was 120 feet. A 14 drill Western and Derby compressor supplies the air for the drill. The work at this mine was begun in February, 1891.

NICKEL.

Discvoery and development.

A visit was made to the Murray mine of Messrs. H. H. Vivian & Co., where there is a mining plant capable of turning out about 50 tons of ore per day, or about 85 tons if desired. In the smelter are two furnaces, one a water-jacketted Jenckes capable of handling 100 tons of ore per day, and the other an ordinary cupola, with fixed fore-hearth, with a capacity of 60 tons of ore.

The cupola matte contains about ten per cent of nickel and five per cent of copper, which percentages are increased by bessemerising to 40 and 20 per cent respectively in the Manhé converter. The product was marketed in Great Britain, the cost of transport being $10 per ton of matte. A force of 142 men was employed, 82 in the mine and 60 in the works.

The force employed by the Canadian Copper Company is stated to have been 500 all told, 470 men in the mines and 30 in the works.

Petroleum.

PETROLEUM.

By H. P. H. Brumell, F.G.S.A.

Production.

PRODUCTION.

Production.—Refining operations were carried on as in past years in Petrolea and London, the number of refineries however being reduced by the closing down of those operated by Messrs, McMillan, Kittredge & Co., the Premier Oil Co., and John McMillan, all in Petrolea.

Those actually in operation were :—

Imperial Oil Co	Petrolea.
Consumers' Oil Refining Co	"
Petrolea Crude Oil and Tanking Co	"
Fairbank, Rogers & Co	"
John McDonald	"
Empire Oil Co	London.

The production of petroleum for the year as given in the summary of the mineral production in Canada, page 5 s, is obtained as in past years by calculation from the inspection returns of the Inland Revenue Department.

During 1893 (calendar year) the inspection of domestic oil was as follows :—

247,122 packages at 10 cents inspection fee.
47,936 " " $2\frac{1}{2}$ " "

Assuming that these packages contain forty-two and five gallons each, respectively, there was a total inspection as follows :—

10,379,124 gallons in packages of 42 gallons each.
239,680 " " 5 "

or a total inspection of 10,618,804 gallons. Computing this at the average proportion of 38 gallons refined to 100 crude oil, there would be shown a total consumption of crude oil of 27,944,221 gallons, or 798,406 barrels, which, at the average price for the year of $1.04\frac{1}{2}$, has a value of $834,334.

From direct returns made to this office very similar figures are obtained. According to these there was a consumption of crude oil of 27,994,805 gallons, or 799,851 barrels, which at the average price quoted above would have a value of $835,844.

The two following tables illustrate the operations of the various refiners according to returns received at this office :—

PETROLEUM.

PETROLEUM.

TABLE 1.

PRODUCTION OF CANADIAN OIL REFINERIES.

Production.

Products.	1892.		1893.		1894.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		$		$		$
Illuminating oils. galls	10,806,806	1,176,720	11,100,810	1,073,738	11,289,741	1,003,973
Benzine and naphtha .... "	793,263	60,130	721,192	54,760	645,031	54,515
Paraffine oils..... "	1,051,161	127,351	1,243,924	116,233	1,282,749	118,053
Gas and fuel oils.. "	6.343,589	202,047	7,559,489	217,740	7,323,374	197,193
Lubricating oils and tar.... ... "	3,177,853	133,336	1,876,633	92,616	1,801,174	74,309
Paraffine wax.... lbs.	876,570	82,781	1,659,167	120,697	1,950,172	119,091
Totals..........	....	1,782,365	....	1,675,784	....	1,567,134

PETROLEUM.

TABLE 2.

CONSUMPTION OF CRUDE OIL AND CHEMICALS.

Articles.	1891.	1892.	1893.	1894.
Crude petroleum. ..galls.	27,860,719	27,218,812	27,994,805	27,884,080
Sulphuric acid.......... lbs.	4,213,984	4,803,301	4,676,353	4,974,610
Soda .. .. "	319,736	369,857	420,047	430,810
Litharge......... .... "	394,715	434,982	470,666	472,139
Sulphur............... "	54,032	73,278	74,012	96,144

The tanking companies operating as such were, as in previous years, The Petrolea Crude Oil and Tanking Company, The Crown Warehousing Company and the Producers' Tanking Company of Petrolea, all of whom kindly furnished us with returns of their year's business. These returns afforded the following results :—

Stocks, 1st January, 1893....... 55,933$\frac{11}{35}$ bbls.
Quantity of oil received ....432,150$\frac{17}{35}$ "
" " delivered ....411,023 "
Stocks, 1st January, 1894........ 77,060$\frac{28}{35}$ "
Increase in stocks, during year... 21,127$\frac{17}{35}$ "

Petroleum.

The increase in stocks held at the end of the year, is no doubt largely due to the fact that the price of crude oil having fallen from \$1.18¼ in January to \$1.02 in December it was being held against a rise.

Inspection of oils.

INSPECTION OF OILS.

The following tables are compiled from the returns of the Inland Revenue Department and show the amounts of refined oil, domestic and imported, inspected annually since 1881.

PETROLEUM.
TABLE 3.
CANADIAN OILS AND NAPHTHA INSPECTED AND CORRESPONDING QUANTITIES OF CRUDE OIL.

Calendar Year.	Refined Oils Inspected.	Crude Equivalent Calculated.	Ratio of Crude to Refined.
	Galls.	Galls.	
1881	6,406,783	12,813,566	100 : 50
1882	5,910,787	13,134,993	100 : 45
1883	6,970,550	15,490,111	100 : 45
1884	7,656,011	19,140,027	100 : 40
1885	7,661,617	19,154,042	100 : 40
1886	8,149,472	21,445,979	100 : 38
1887	8,243,962	21,694,637	100 : 38
1888	9,545,895	25,120,776	100 : 38
1889	9,462,834	24,902,195	100 : 38
1890	10,121,210	26,634,763	100 : 38
1891	10,270,107	27,026,597	100 : 38
1892	10,370,707	27,291,334	100 : 38
1893	10,618,804	27,944,221	100 : 38
1894	11,027,082	29,018,637	100 : 38

PETROLEUM.
TABLE 4.
TOTAL AMOUNT OF OIL INSPECTED, IMPORTED AND CANADIAN.

Calendar Year.	Imported.	Canadian.	Total.
	Galls.	Galls.	Galls.
1881	476,784	6,406,783	6,883,567
1882	1,351,412	5,910,747	7,262,159
1883	1,190,828	6,970,550	8,161,378
1884	1,142,575	7,656,011	8,798,586
1885	1,278,115	7,661,617	8,939,732
1886	1,327,616	8,149,472	9,477,088
1887	1,665,604	8,243,962	9,909,566
1888	1,821,342	9,545,895	11,367,237
1889	1,767,812	9,462,834	11,230,646
1890	2,020,742	10,121,210	12,141,952
1891	2,022,002	10,270,107	12,292,109
1892	2,601,946	10,370,707	12,972,653
1893	4,520,392	10,618,804	15,139,196
1894	5,705,787	11,027,082	16,732,869

EXPORTS AND IMPORTS. PETROLEUM.

The following tables of exports and imports of oil are compiled from information obtained from the Customs Department. Exports and imports.

PETROLEUM.

TABLE 5.

EXPORTS OF CRUDE AND REFINED PETROLEUM.

Calendar Year.	Crude Oil.		Refined Oil.		Total.	
	Gallons.	Value.	Gallons.	Value.	Gallons.	Value.
1881	....	....	....	....	501	$ 99
1882	....	.. ..	....	....	1,119	286
1883	... .	....	....	....	13,283	710
1884	....	....	....	....	1,098,090	30,168
1885	....	....	....	....	337,967	10,562
1886	....	....	....	....	241,716	9,855
1887	....	....	....	....	473,559	13,831
1888	......	....	....	....	196,602	74,542
1889	....	....	....	....	235,855	10,777
1890	....	....	....	....	420,492	18,154
1891	446,770	$18,471	585	$104	447,355	18,575
1892	310,387	12,945	1,146	100	311,533	13,045
1893	107,719	3,696	2,196	394	109,915	4,090
1894	53,985	2,773	5,297	513	59,282	3,286

PETROLEUM.

TABLE 6.

IMPORTS OF CRUDE AND REFINED PETROLEUM.

Fiscal Year.	Gallons.	Value.
1880	687,641	$131,359
1881.......	1,437,475	262,168
1882......................	3,007,702	398,031
1883....	3,086,316	358,546
1884..................	3,160,282	380,082
1885......................	3,767,441	415,195
1886......................	3,819,146	421,836
1887.	4,290,003	467,003
1888......................	4,523,056	408,025
1889......................	4,650,274	484,462
1890......	5,075,650	515,852
1891.....	5,071,386	498,330
1892......................	5,649,145	475,732
1893................. ..	6,002,141	446,389
1894	6,597,108	439,988

PETROLEUM.

Exports and imports.

Subtracting the quantity of imported oil inspected annually (table 4) from that shown in table 6, there will be found to have been an importation of oil, crude and other than illuminating, as follows :—

PETROLEUM.

TABLE 7.

IMPORTS OF CRUDE AND MANUFACTURED OILS, OTHER THAN ILLUMINATING.

Fiscal Year.	Gallons.
1881	960,691
1882	1,656,290
1883	1,895,488
1884	2,017,707
1885	2,489,326
1886	2,491,530
1887	2,624,399
1888	2,701,714
1889	2,882,462
1890	3,054,908
1891	3,049,384
1892	3,047,199
1893	1,481,749
1894	1,860,829

The above-shown importation consists largely of heavy black oil for railway purposes and other heavy lubricants, though in what proportion it is impossible to ascertain.

The imports of paraffine wax and paraffine wax candles are shown in the two following tables :

PETROLEUM.

TABLE 8.

IMPORTS OF PARAFFINE WAX.

Fiscal Year.	Pounds.	Value.
1883	43,716	$ 5,166
1884	39,010	6,079
1885	59,967	8,123
1886	62,035	7,953
1887	61,132	6,796
1888	53,862	4,930
1889	63,229	5,250
1890	239,229	15,844
1891	753,854	50,275
1892	733,873	48,776
1893	452,916	38,935
1894	208,099	15,704

PETROLEUM.

PETROLEUM.

TABLE 9.

IMPORTS OF PARAFFINE WAX CANDLES.

Exports and imports.

Fiscal Year.	Pounds.	Value.
1880	10,445	$2,269
1881	7,494	1,683
1882	5,818	1,428
1883	7,149	1,734
1884	8,755	2,229
1885	9,247	2,449
1886	12,242	2,587
1887	21,364	3,611
1888	22,054	2,829
1889	8,038	1,337
1890	7,233	1,186
1891	10,598	2,116
1892	9,259	1,952
1893	8,351	1,735
1894	10,818	1,685

DISCOVERY AND DEVELOPMENT.

Discovery and development in Ontario.

ONTARIO.

There is practically nothing to report under this heading for the year. As in previous years, the whole source of supply is situated in Enniskillen township, Lambton county, Ontario, throughout which the usual amount of drilling was performed. As usual, many new wells were sunk, and practically a corresponding number abandoned, there being still about 5,000 wells, producing on an average about half a barrel per day.

As in previous years we are indebted to Mr. James Kerr, secretary of the Petrolea Oil Exchange, for the following prices of crude oil during the year; the prices quoted are those recorded on the Exchange.

Petroleum.

Discovery and development in Ontario.

Average Closing Prices for Crude Oil.

Month.	1891.	1892.	1893.	1894.
	$	$	$	$
January..	1 30	1 29¼	1 18¼	1 01¼
February............	1 28½	1 29	1 18¾	1 01
March.............	1 31¾	1 27¾	1 19	1 01
April..............	1 37	1 26	1 19	99½
May..............	1 37½	1 25¾	1 07	92
June..	1 37	1 27½	1 07	92¾
July...............	1 33½	1 26½	1 06	94
August...........	1 34¾	1 26	1 05	96
September..........	1 35	1 26¼	1 04½	98
October..........	1 35	1 26¾	1 04	1 06
November..........	1 33¼	1 25	1 04	1 12¼
December..........	1 31½	1 18½	1 02	1 13½
The Year............	1 33¾	1 26¼	1 09½	1 00¾

Discovery and development in Quebec.

QUEBEC.

Prospecting operations were being carried on by the Petroleum Oil Trust in the neighbourhood of Gaspé Basin, where several new wells were begun. Although small quantities of oil are known to have been obtained, no particulars of this exploratory work are available.

Phosphate.

PHOSPHATE.

Production.

The continued falling off in the production of Canadian phosphate (apatite) mines which began in 1890, is evident again in the figures for 1893 which are less than those of 1892 by 3,734 tons and $86,482.

On account of the disorganized state of the industry, it was found impossible to get satisfactory and complete returns direct from the operators, and, as the various estimates of total output received show considerable discrepancies, the exports have been taken as probably the most correct. By adding thereto the amount of mineral known to have been used in the country, the figures of production have been arrived at.

The following figures give the production for several years :—

1886............	20,495 tons,	valued at	$304,338
1887............	23,690	"	319,815
1888............	22,485	"	242,285
1889............	30,988	"	316,662
1890............	31,753	"	361,045
1891............	23,588	"	241,603
1892............	11,932	"	157,424
1893............	8,198	"	70,942
1894............	6,861	"	41,166

EXPORTS AND IMPORTS. PHOSPHATE.

Exports and imports.

Table 1, following, gives the exports of the mineral by provinces. Of the total amount of 7,738 tons, there shown for 1893, all that proportion entered at Ontario ports went to the United States and the remainder to Great Britain. No crude phosphate was imported.

Table 2 shows the position occupied by Canadian apatite in the British market. This brings to light the same unfortunate falling off noticeable in the figures of production.

PHOSPHATE.

TABLE 1.

EXPORTS OF PHOSPHATE.

Year.	Ontario.		Quebec.	
	Tons.	Value.	Tons.	Value.
1878	824	$12,278	9,919	$195,831
1879	1,842	20,565	6,604	101,470
1880	1,387	14,422	11,673	175,664
1881	2,471	36,117	9,497	182,339
1882	568	6,338	16,585	302,019
1883	50	500	19,666	427,168
1884	763	8,890	20,946	415,350
1885	434	5,962	28,535	490,331
1886	644	5,816	19,796	337,191
1887	705	8,277	22,447	424,940
1888	2,643	30,247	16,133	268,362
1889	3,547	38,833	26,440	355,935
1890	1,866	21,329	26,591	478,040
1891	1,551	16,646	15,720	368,015
1892	1,501	12,544	9,981	141,221
1893	1,990	11,550	5,748	56,402
1894	1,980	10,560	3,470	29,610

PHOSPHATE.

Exports and imports.

PHOSPHATE.

TABLE 2.

GREAT BRITAIN : IMPORTS OF CANADIAN APATITE COMPARED WITH TOTAL IMPORTS OF PHOSPHATES IN THAT COUNTRY.

Year.	Canadian Apatite.		Total Phosphates.		Per cent of Value of Canadian Apatite to total Value.
	Long Tons — 2,240 lbs.	£ stg.	Long Tons — 2,240 lbs.	£ stg.	
1882	8,187	39,851	199,428	613,198	6·5 per cent.
1883	16,531	66,714	246,945	813,825	8·2 "
1884	15,716	52,370	219,225	643,851	8·1 "
1885	21,484	76,179	238,572	628,027	12·1 "
1886	18,069	63,490	223,111	526,885	12·0 "
1887	19,194	65,974	283,415	614,088	10·7 "
1888	12,423	42,291	257,886	544,919	7·7 "
1889	23,123	71,037	304,953	703,704	10·1 "
1890	21,089	65,420	343,501	849,452	7·8 "
1891	15,918	54,235	256,772	628,395	8·6 "
1892	7,814	17,763	314,130	665,689	2·7 "
1893	5,063	11,735	323,527	594,467	1·9 "

Discovery and development.

DISCOVERY AND DEVELOPMENT.

The depression, due to competition with the phosphate producing districts of the Southern States and other new fields, still continues; so that no attention has been paid to prospecting for the mineral.

Small lots were produced as a by-product at many of the mica mines working in eastern Ontario and western Quebec.

The larger portion of the product was shipped from the Rivière du Lièvre district in Ottawa county, Quebec. Small lots of mineral mined in previous years were shipped from the High Falls, Central Lake and North Star mines by the General Phosphate Corporation, but the only mining of any extent was done by the Phosphate of Lime Company at their mine at High Rock where about thirty men were employed, and by the Anglo-Continental Guano Company at the Squaw Hill and Ætna mines. At the latter place the diamond drill was brought into use—it is claimed with success—in prospecting ahead of the workings for other bodies of the mineral.

In Ontario the only shipments of any extent were made by the Opinicon and Nicholson mines.

PHOSPHATE.
Annual Exports.
Table A.

Year.	Tons.	Value.
		$
1878	10,743	208,109
1879	8,446	122,035
1880	13,060	190,086
1881	11,968	218,456
1882	17,153	338,357
1883	19,716	427,668
1884	21,709	424,240
1885	28,969	496,293
1886	20,440	343,007
1887	23,152	433,217
1888	18,776	298,609
1889	29,987	394,768
1890	28,457	499,369
1891	17,271	384,661
1892	11,482	153,764
1893	7,738	67,952
1894	5,450	40,170

PRECIOUS METALS.

Gold.

Production.

THE PRECIOUS METALS.

GOLD.

PRODUCTION.

The production of this metal during 1893 amounted to 54,410 oz., valued at $976,603. These figures show an increase over those of 1892 of about eight per cent, as compared with a falling off of about two per cent from 1891 to 1892.

Table 1, below, gives the amounts contributed by the various provinces to the grand total.

GOLD.

TABLE 1.

PRODUCTION BY PROVINCES.

1893.

Provinces.	Ounces.	Value.
Nova Scotia	19,543	$381,095
Quebec	872	15,696
Ontario	749	14,637
North-west Territories (including Yukon District)	10,920	185,640
British Columbia	22,326	379,535
Total	54,410	$976,603

GOLD.

TABLE 1a.

PRODUCTION BY PROVINCES.

1894.

Provinces.	Ounces.	Value.
Nova Scotia	19,342	$377,169
Quebec	1,622	29,196
Ontario	2,032	39,624
North-west Territories (including Yukon District)	8,235	140,000
British Columbia	26,827	456,066
Total	58,058	$1,042,055

PRECIOUS METALS.

Gold.

Production.

The provinces of Nova Scotia and British Columbia continue to be the largest contributors, the one from its quartz mining operations and the other from the working of its placer deposits. The item designated North-west Territories (including Yukon District) includes a small amount of the precious metal washed from the bars of the Saskatchewan River, but the most is to be credited to the placer workings in the Canadian Yukon district which is estimated as closely as possible by those who know the ground.

Compared with last year's figures, Nova Scotia shows a decrease of 455 oz., and British Columbia 1,175 oz., whilst increases are shown for Quebec of 151 oz., Ontario 384 oz., and the North-west Territories of 5,155 oz.

BRITISH COLUMBIA.

British Columbia.

The accompanying graphic tables A, B and C give statistical details of the gold production of British Columbia as compiled from the report of the Minister of Mines for that province. As formerly, this represents the amount of gold actually known to have been exported by the banks, plus one-fifth estimated to have been carried away in private hands.

GOLD.
British Columbia.
Annual Production.
Table A.

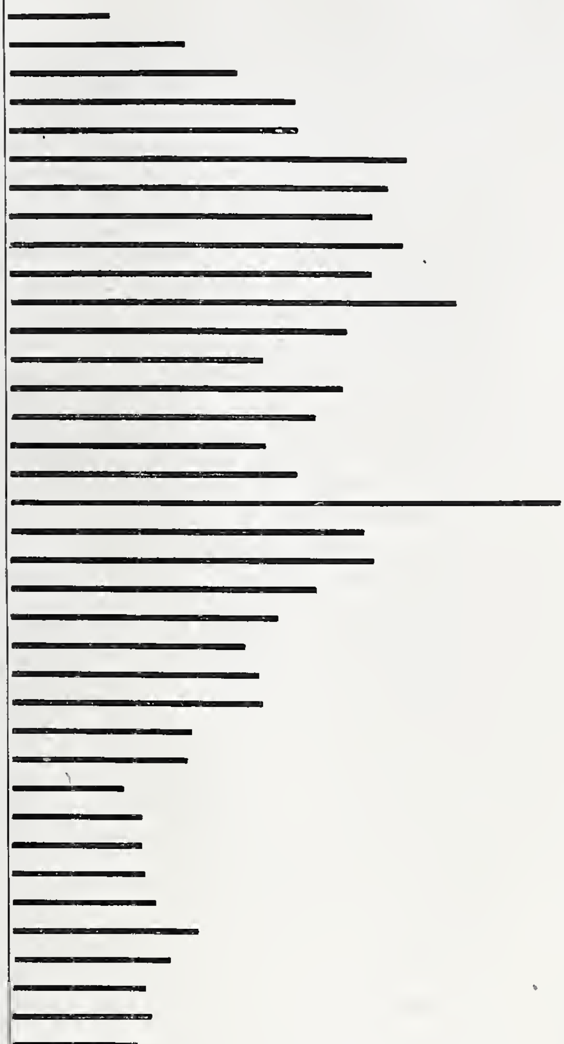
Year.	Value.
	$
1858	705,000
1859	1,615,072
1860	2,228,543
1861	2,661,118
1862	2,656,903
1863	3,913,563
1864	3,735,850
1865	3,491,205
1866	2,662,106
1867	2,480,868
1868	2,372,972
1869	1,774,978
1870	1,336,956
1871	1,799,440
1872	1,610,972
1873	1,305,749
1874	1,844,618
1875	2,474,904
1876	1,786,648
1877	1,608,182
1878	2,275,204
1879	1,290,058
1880	1,013,827
1881	1,046,737
1882	954,085
1883	794,252
1884	736,165
1885	713,738
1886	903,651
1887	693,709
1888	616,731
1889	588,923
1890	494,436
1891	429,811
1892	399,525
1893	379,535
1894	456,066

PRECIOUS METALS.

Gold.

GOLD.
BRITISH COLUMBIA.
EARNINGS PER MAN.
Table B.

Year.	Value.
	$
1858	235
1859	403
1860	506
1861	634
1862	648
1863	889
1864	849
1865	813
1866	893
1867	814
1868	992
1869	749
1870	569
1871	734
1872	671
1873	567
1874	643
1875	1,222
1876	783
1877	820
1878	677
1879	607
1880	518
1881	551
1882	548
1883	404
1884	396
1885	246
1886	287
1887	296
1888	307
1889	330
1890	423
1891	358
1892	298
1893	304
1894	283

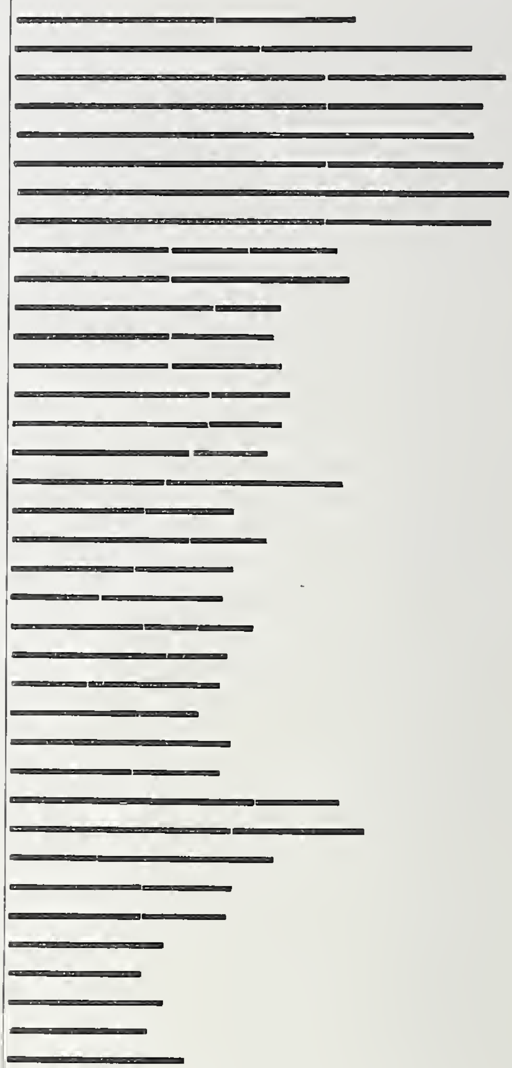


Precious metals.

Gold.

GOLD.
British Columbia.
Number of Men Employed.
Table C.

Year.	Number.
1858	3,000
1859	4,000
1860	4,400
1861	4,200
1862	4,100
1863	4,400
1864	4,400
1865	4,294
1866	2,982
1867	3,044
1868	2,390
1869	2,369
1870	2,348
1871	2,450
1872	2,400
1873	2,300
1874	2,868
1875	2,024
1876	2,282
1877	1,960
1878	1,883
1879	2,124
1880	1,955
1881	1,898
1882	1,738
1883	1,965
1884	1,858
1885	2,902
1886	3,147
1887	2,342
1888	2,007
1889	1,929
1890	1,342
1891	1,199
1892	1,340
1893	1,247
1894	1,610



PRECIOUS METALS.

Gold.

GOLD.

TABLE 2—1893.

YIELD, ETC., BY DISTRICTS.

District.	Division.	Men Employed.		Yield of gold by Divisions.	Total yield by Districts.
		Whites.	Chinese.		
				$	$
Caribou..........	Barkerville	83	136	73,000	
	Lightning Creek....	29	139	49,000	
	Quesnelle Mouth....	7	92	25,450	
	Keithley Creek......	68	196	54,550	
		187	563		202,000
Cassiar..........	Laketown	14	30	10,909	
	McDame Creek.....	4	25	9,876	
	Liard River..	20	3	1,700	
	Stikine.......... ..	1	3	450	
		39	61		22,935
Kootenay........	Eastern	27	43	19,700	
	Western	....	....	6,150	
	Trail Creek sub-div'n	....	....	4,000	
	Nelson "	....	....	6,000	
		27	43		35,850
Lillooet.	....	35	55	51,376	51,376
Yale............	Yale....	....	....	3,800	
	Osoyoos	118	39	18,254	
	Similkameen........	29	53	14,340	
		147	92		37,394
	Total, Whites......	435	.. . .		
	" Chinese......	....	814		
	" employed ...	1,249			349,555

PRECIOUS METALS.

Gold.

GOLD.

TABLE 2*a*—1894.

YIELD, ETC., BY DISTRICTS.

District.	Division.	Men Employed. Whites.	Men Employed. Chinese.	Yield of gold by Divisions.	Total yield by Districts.
				$	$
Cariboo	Barkerville	87	149	66,300	
	Lightning Creek	27	100	34,700	
	Quesnelle Mouth	37	78	26,200	
	Keithley Creek	167	199	65,150	192,350
		318	526		
Cassiar	Laketown	11	34	12,300	
	McDame Creek	6	20	9,750	
	Liard River	....	....	350	
	Stikine	....	....	300	22,700
		17	54		
Kootenay	Eastern	41	43	24,900	
	Western	205	3	37,780	62,680
		246	46		
Lillooet	....	30	50		39,257
Yale	Osoyoos	138	40	65,150	
	Similkameen	75	70	11,805	76,955
		213	110		
	Total, Whites	824	....		
	" Chinese	....	786		
	" employed	1,610			393,942

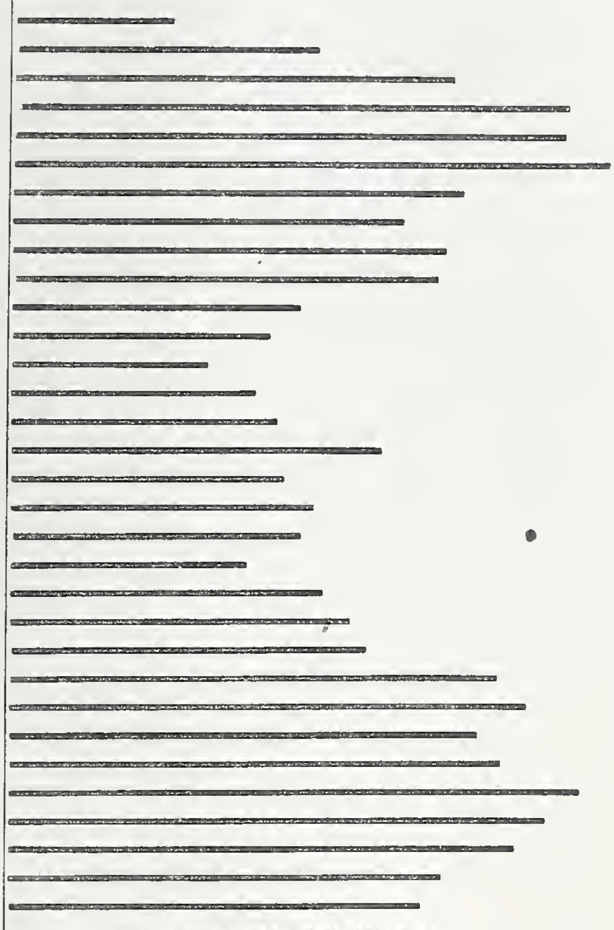
Nova Scotia.

Precious metals.
Gold.
Production.
Nova Scotia.

The following tables, D, E and F, are compiled from data given in the reports of the Department of Mines in Nova Scotia. It will be noticed that the total production of gold continues to fall off and that whilst the number of tons crushed has increased the yield per ton is much less than in any previous year.

GOLD.
Nova Scotia.
Annual Production.
Table D.

Year.	Value.
	$
1862	141,871
1863	272,448
1864	390,349
1865	496,357
1866	491,491
1867	532,563
1868	400,555
1869	348,427
1870	387,392
1871	374,972
1872	255,349
1873	231,122
1874	178,244
1875	218,629
1876	233,585
1877	329,205
1878	245,253
1879	268,328
1880	257,823
1881	209,755
1882	275,090
1883	301,207
1884	313,554
1885	432,971
1886	455,564
1887	413,631
1888	436,939
1889	510,022
1890	474,990
1891	451,511
1892	389,965
1893	367,556
1894	377,169



PRECIOUS METALS.

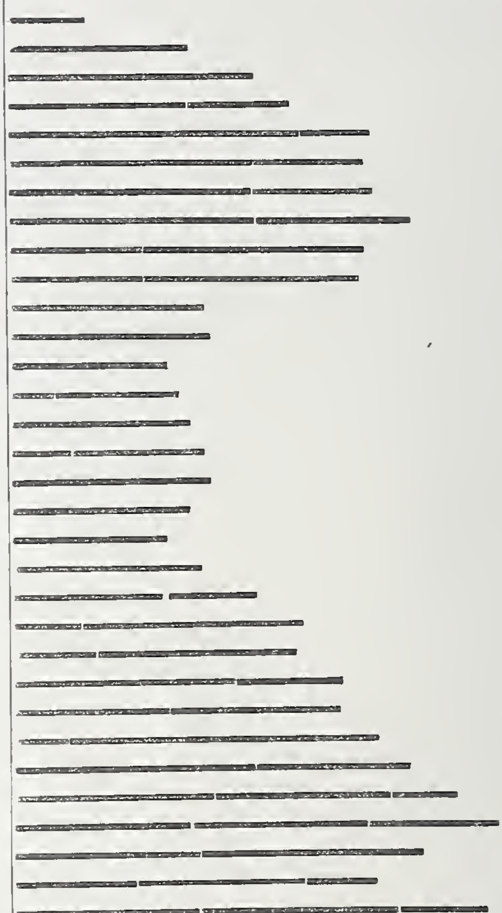
Gold.

Production.

Nova Scotia.

GOLD.
NOVA SCOTIA,
TONS OF QUARTZ CRUSHED.
Table E.

Year.	Tons.
1862	6,473
1863	17,000
1864	21,431
1865	24,421
1866	32,157
1867	31,384
1868	32,259
1869	35,144
1870	30,824
1871	30,787
1872	17,089
1873	17,708
1874	13,844
1875	14,810
1876	15,490
1877	17,369
1878	17,989
1879	15,936
1880	13,997
1881	16,556
1882	21,081
1883	25,954
1884	25,186
1885	28,890
1886	29,010
1887	32,280
1888	36,178
1889	39,160
1890	42,749
1891	36,351
1892	32,552
1893	42,354



PRECIOUS METALS.

Gold.

Production.

Nova Scotia.

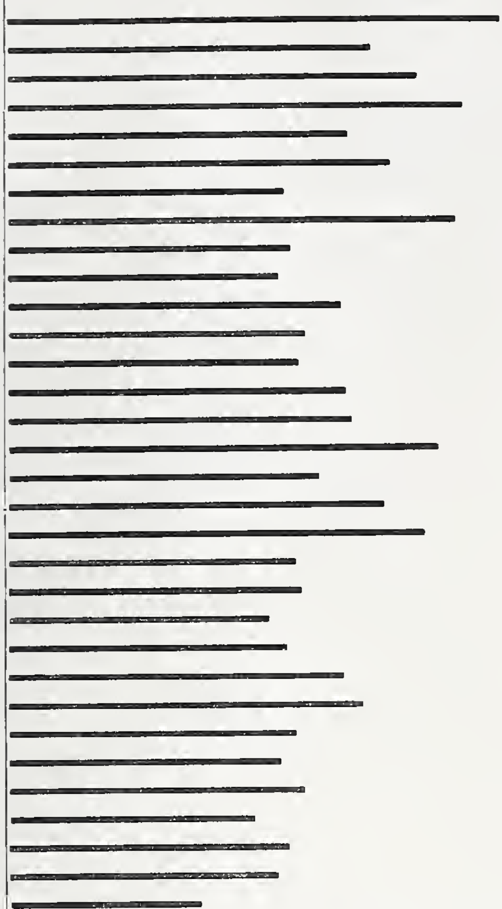
GOLD.

NOVA SCOTIA.

AVERAGE YIELD PER TON OF ORE CRUSHED.

Table F.

Year.	Value.
	$
1862	21·91
1863	16·02
1864	18·11
1865	20·32
1866	15·28
1867	16·96
1868	12·41
1869	19·91
1870	12·56
1871	12·17
1872	14·81
1873	13·05
1874	12·87
1875	14·89
1876	15·08
1877	19·01
1878	13·63
1879	16 83
1880	18·42
1881	12·66
1882	13·04
1883	11·60
1884	12·44
1885	14·98
1886	15·70
1887	12·81
1888	12·08
1889	13·02
1890	11·11
1891	12·42
1892	11·98
1893	8·68



PRECIOUS METALS

Gold.

Production.

Nova Scotia.

GOLD

TABLE 3.

PRODUCTION OF THE DIFFERENT DISTRICTS, FROM 1862 TO 1893, INCLUSIVE.

Districts.	Tons of ore crushed.	Total Yield.				Average yield per ton of 2,000 lbs.
		Oz.	Dwt.	Grs.	Value at $19.50 per oz.	
Caribou & Moose River	56,901	27,913	2	5	$ 544,306	$ 9·56
Montague	17,945	34,596	4	0	674,626	37·59
Oldham	42,953	47,558	2	18	927,383	21·59
Renfrew	46,071	31,814	13	2	620,385	13·46
Sherbrooke	166,295	119,767	9	2	2,335,465	14·04
Stormont	34,833	29,409	12	23	573,489	16·46
Tangier and Mooseland	30,705	19,604	12	19	382,290	12·45
Uniacke	40,032	26,201	11	13	510,931	12·76
Waverly	102,842	56,586	18	14	1,103,445	10·73
Salmon River	43,355	13,086	4	0	255,181	5·88
Brookfield	5,663	4,858	4	9	94,735	16·73
Whiteburn	6,879	9,904	19	20	193,148	28·01
Lake Catcha	8,124	8,393	19	3	163,683	20·15
Rawdon	11,389	9,060	14	4	176,683	15·68
Killag	379	354	6	16	6,909	18·23
Wine Harbour	41,798	28,639	6	1	558,466	13·36
Darr's Hill	39,909	18,715	19	19	364,962	9·14
Fifteen Mile Stream	14,764	8,044	19	5	156.877	10·62
Malaga	15,847	12,687	4	18	247,401	15·61
Unproclaimed	55,177	42,047	11	9	819,928	14·86
Totals	781,861	549,245	16	8	$10,710,293	$13·69

GOLD.

TABLE 4.

DISTRICT DETAILS.—1893.

Districts.	Mines.	Mills.	Tons of Ore Crushed.	Total yield of Gold.			Total yield of Gold per ton.		
				Oz.	Dwt.	Grs.	Oz.	Dwt.	Grs.
Tangier / Mooseland	1	1	1,213	406	4	13	0	6	16
Oldham	2	2	2,787	3,406	6	2	1	4	6
Caribou / Moose River	3	3	7,141	2,371	4	19	0	7	15
Stormont	3	3	11,709	5,143	6	14	0	8	19
Salmon River	1	..	3,570	965	0	0	0	5	9
Montague	2	..	890	653	11	8	0	14	16
Lake Catcha	2	2	1,665	963	0	0	0	11	14
Fifteen Mile Stream	1	1	1,401	497	17	0	0	7	2
Uniacke	2	3	825	1,305	9	5	1	11	15
Waverly	1	1	8,150	2,110	15	0	0	5	4
Whiteburn	1	1	1,004	623	17	0	0	12	10
Unproclaimed, etc	4	4	1,999	1,096	15	12	0	10	23
Totals and averages	23	21	42,354	19,543	7	1	0	9	5

PRECIOUS METALS.

Gold.

Production.

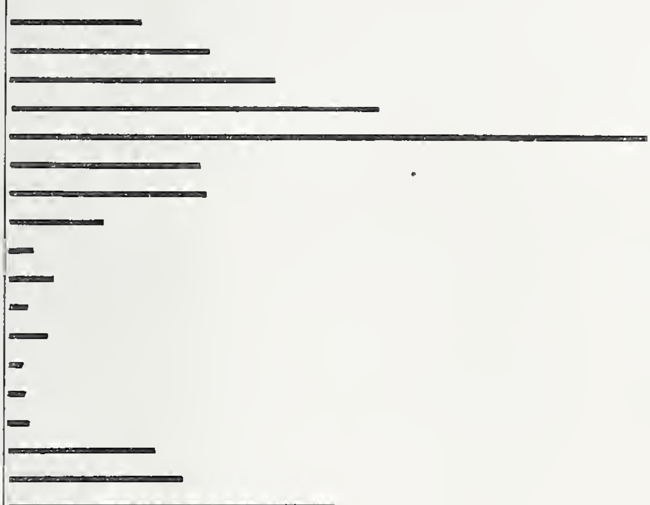
Quebec.

QUEBEC.

Reference to graphic table G shows an encouraging increase in the figures of production due to the continuance of greater activity in mining in this province.

GOLD.
QUEBEC.
ANNUAL PPODUCTION.
Table G.

Year.	Value.
	$
1877	12,057
1878	17,937
1879	23,972
1880	33,174
1881	56,661
1882	17,093
1883	17,787
1884	8,720
1885	2,120
1886	3,981
1887	1,604
1888	3,563
1889	1,207
1890	1,350
1891	1,800
1892	12,987
1893	15,696
1894	29,196



NORTH-WEST TERRITORIES, ETC.

The increase shown in this item is due to the greater activity of placer washing in the Yukon district.

SILVER.

Silver.

Production.

The production of silver for 1893 amounted to $330,128 subdivided as shown in table 1, from which it will be seen that there is a falling off both in Ontario and Quebec; in very large proportion in the latter. These deficits are more than made up by the very large increase of over 200 per cent in the value of British Columbia's production. The figures given represent the value of the silver contents of the ship-

PRECIOUS METALS.

Silver.

Production.

ments of ore made by the various mines at the average market price of that metal for 1893, viz., 77 cents per ounce.

The figures credited to Ontario represent the shipments of silver bearing ores from the Port Arthur district, as per export entries made to the custom house. Those for Quebec represent as in former years the silver contents of the cupreous pyrites ores shipped from the Capelton group of mines. Owing to the as yet unorganized condition of the mining industry of British Columbia, it was found impossible to get complete returns from the various operators. The figures available were the export entries of shipments made to customs officers in the province, checked by the figures of imports of British Columbia ores into the States, where all the mineral finds a sale for the present. Further data were obtained from well informed persons living in the districts who had means of obtaining the required information, and from a comparison of all these the figures given below were obtained.

SILVER.

TABLE 1.

PRODUCTION OF SILVER.

Year.	Ontario.		Quebec.		British Columbia.		Total.	
	Oz.	Value.	Oz.	Value.	Oz.	Value.	Oz.	Value.
1887.....	190,495	$190,495	146,898	$146,898	11,937	$11,937	349,330	$349,330
1888.....	208,064	208,064	149,388	149,388	37,925	37,925	395,377	395,377
1889.....	181,609	162,309	148,517	133,666	53,192	47,873	383,318	343,848
1890.....	158,715	166,652	171,545	180,122	70,427	73,948	400,687	420,722
1891.....	225,633	221,120	185,584	181,872	3,306	3,241	414,523	406,233
1892.....	41,581	36,072	191,910	166 482	77,160	66,935	310,651	269,489
1893.....	....	8,689	....	126,439	....	195,000	....	330,128
1894.....	....	....	101,318	63,830	746,379	470,219	847,697	534,049

The continued drop in the price of the metal is of course a great factor affecting the prosperity of the industry. The falling off in the average price has been from 98 cents for 1891; 86 cents for 1892 to 77 cents for 1893*.

Table 2 below gives the exports of silver ore for this and previous years and is compiled from data supplied by the Customs Department.

* See Table of Prices at end of report.

PRECIOUS METALS.

Silver.

Exports.

SILVER.

TABLE 2.

EXPORTS OF SILVER ORE.

Provinces.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
	$	$	$	$	$	$	$
Ontario	208,064	203,871	203,142	222,071	35,992	7,878	....
Quebec	5	2,500	900	.. ....	....	....	....
Nova Scotia	....	50	....	.. ..	....	....	....
Manitoba	....	5	......	....	80	820	....
British Columbia..	10,939	5,737	100	3,241	20,616	204,997	359,731
Totals.........	219,008	212,163	204,142	225,312	56,688	213,695	359,731

Discovery and development.

DISCOVERY AND DEVELOPMENT.

GOLD AND SILVER.

Nova Scotia.

NOVA SCOTIA.

The below given data relating to gold mining operations are summarized from the notes of Mr. Wm. Maddin, jr., in the report of the Minister of Mines for the province.

He draws attention to the indications of gold in the new West Caledonia district, Queen's county, and expresses his belief that there appears to be every probability of the existence of gold bearing veins here and at many other places in the western counties quite as rich as any known east of Halifax, and goes on to say : "In this county gold mining is not so actively prosecuted as hitherto, although some of the best equipped mines in the province are standing idle with very little work done to develop the properties, so little in some instances that they are practically undeveloped to any extent. I am pleased to state, however, there are tangible signs of improvement in this industry. No accidents of any consequence have occurred during the past nine months in gold mining.

"I would like to say that in this country wherever gold mining has been prosecuted, a very large amount of labour, time and money have been spent in prospecting and working our gold fields, the extent of which cannot be seen anywhere, nor can the result of these operations be shown. In my opinion this is a serious misfortune, as if accurate plans, surveys, and records of such work were filed in some place available to the mining capitalist, it would eventually save a large amount of loss and be a source of information that would be profitable hereafter."

In the latter remarks, everyone with any knowledge of mining will quite concur, having in mind the true interests of the industry.

The following tabulations contain, in a condensed form, the information as to discovery and development in gold mining contained in the reports of the Department of Mines for the province.

Name of Mine.	Force employed.	Shafts.	Other underground Developments, Tunnels, Drifts, Winzes, &c.	Mining Plant and Additions to.	Milling Plant and Operations.	Remarks.
Crows' Nest Mine						Nothing of importance during the year.
Cochran Hill Mine	4		Some trenching done and otherwise prospecting.		Trial crushing made.	Several gold bearing leads exposed.
Country Harbour Mine.	35	Depth 109 feet			20-stamp mill	
Copeland Mine	31	" 130 "			15-stamp mill	
North Star Mine	30	" 500 "	Inclines exposing two new veins at 50 and 80 feet.	Ventilating fan 39 ins in diameter; blades 10 x 24 inches, run by mill engine at 200 to 300 revolutions per minute.		At Isaac Harbour.
Richardson Mine	28	Depth 90 feet; still sinking.			20-stamp mill	About 1½ mile from the main post-road on the northern side of Isaac's Harbour.
Near Richardson Mine.						An old mine being opened up and preparations being made for active work; new machinery being erected.
Goldenville						Very little doing except prospecting.
Ecum Secum Mine						Idle when visited; resumption of work contemplated.
Dufferin Mine	40	Depth 300 feet and sinking.	Opening on "5 feet vein" N. of old south vein.			The shaft is being sunk to cut the "12 feet vein" lying south.
Oxford Gold Mining Co.	20				Considerable amount of "surface" ore crushed with good results.	Work done principally on Coleman lead.
Anderson Mine	8	Three shafts down 40 feet.	Working a vein west of the old works.			The vein worked, and the district in general looking well.

Montague........	36	Depth 265 feet and sinking.	....	Considerable amount of building and re-modelling of buildings and machinery	....	Expenditure considerable.
Salisbury Gold Mining Co.	18	Depth 65 feet; working on an old shaft.	....	Large trestle erected from pit head to mill house.	Five stamp mill....	
Simons Kaye Mine.	11	Depth 90 feet; still sinking.	....	....	New millhouse and 10-stamp mill erected.	Expenditure considerable.
West Waverly Mine	60	Depth of shaft 230 ft.	Tunnel driven N. 125 feet and S. 256 feet, cross-cutting 6 leads; "Dominion lead" stoped 300 feet E. and 175 feet W.; "Tudor lead" stoped 86 feet E and 144 feet W.	....	10 more stamps added making it now a 20-stamp mill.	
East Waverly Mine.	..	....	A large amount of preliminary work done; Tunnel in 625 feet to "Barrel lead"; upraise made at the face to the surface 300 feet; levels driven about 500 feet on each dip of the vein; about 250 tons have been broken down and about 1,000 tons are standing.	Arrangements completed for plant, compressor, &c.	....	
Oldham......	50	Shaft or incline down 475 feet; shaft sinking on "Napier lead" now down 134 feet. A well timbered perpendicular shaft cuts these leads.	Lead stoped 900 feet E and 800 feet W.; several leads exposed by cross-cuts driven 150 feet N 50 feet S. The "Blackie lead" has been opened up 140 feet E. and W. No. 6 lead opened up on the N. dip 40 feet and S. 25 feet. Of the "No. 5" and "Harrison leads" 100 feet opened up.	....	....	
The Caledonia Mining Co.	15	Depth 100 feet	Driving a tunnel N. 125 feet to date, cutting three leads.	....	....	
Rhode Island Mining Co.	6	Depth 260 feet......	Working the Dunbrack lead.	....	....	
Montreal Co.......	22	....	....	....	....	
Caribou Truro Mining Co,	16	Sinking on W. or Mill shaft.	Cross-cut driving at E. end of tunnel at a depth of 100 feet.	....	....	Sinking to cut the rich vein discovered last year in the E. shaft.
Old Lake Lead Mine	..	....	....	....	....	Re-opening, unwatering and re-timbering.

Discovery and Development in Gold Mining—*Concluded.*

Name of Mine.	Force employed.	Shafts.	Other underground Developments, Tunnels, Drifts, Winzes, &c.	Mining Plant and Additions to.	Milling Plant and Operations.	Remarks.
Old Caffery property	4	....	....	....	....	
McLeod & Anderson		Sinking perpendicular shaft in saddle to cut a 10 to 12-foot lead.	....	....	....	
Dixon Mine........	20	Shaft down 180 feet.	350 feet of vein opened up; preparing to cross-cut E. and W.; anticipate cutting another vein.	....	....	
Fifteen Mile Stream	24	Shaft now working 90 feet deep.	Tunnel driven S. 143 feet cutting two leads.	Well equipped with machinery; Duplex hoisting engine; high pressure cylinder 7 inches in diameter, low pressure cylinder 14 inches; compressor with a capacity of 6 drills.	15-stamp mill with engine similar to the hoisting engine.	
McLeod & Sutherland areas.	..	....	Considerable prospecting going on.	....	....	E. and W. of Egerton respectively.
N. Brookfield District.	.	....	....	....	....	Idle for some time past; but in September some improvements begun on the machinery, and at date of visit (September) nearly ready to begin operations.
Malaga District (Boston Gold Co.)	25	Two shafts; one 30 feet the other 40 feet deep.	....	Good air compressor.	Good crusher and 10-stamp mill.	All the other mines in this district idle at the time visited (September) except some prospecting on Parker-Douglas property. Four or five well equipped properties standing idle.

Whiteburn District (Crocker Gold Mining Co.)	25	Deepest shaft 180 ft.; in all five shafts ranging from 40 to 180 feet deep almost ready for work.	....	Extensive repairs made by present management.	10-stamp mill..	Several equipped properties in this district standing idle.
(Whiteburn Mining Co.)	8	....	Trenching	....	....	A large number of veins exposed, three or four of which look well on the surface.
West Caledonia....	..	....	....	....	....	A new mining district lately discovered lying 4 to 5 miles W. of Whiteburn mines. Four or five veins exposed showing gold.

PRECIOUS METALS.

QUEBEC.

Discovery and development.

Quebec.

The work of prospecting the gold deposits of the Chaudère River district, was continued during the year 1893, by the American Gold Mining Company, on the River Gilbert, and by Messrs. Haycock & Co., on the Rivière du Loup, both tributaries of the Chaudière River, near St. Francis, Beauce County.

Gold.

The American Gold Mining Co., of Portland, Me., employed a force of about thirty men for five months on preliminary work, building offices, etc., steam saw-mill and everything essential to carrying on extensive work next season. The gold resulting from these experimental, but roughly systematic operations, was taken from ground which, however, is said to have yielded about $1.35 per cubic yard. The force mentioned included carpenters and surface labourers, as well as those actually engaged in mining. The paid-up capital of this company is said to be $200,000.

The Star Mining Co.—Mr. E. B. Haycock, who has mining rights extending four miles along the Rivière du Loup and four miles along the Chaudière, continued operations on the former river, building a dam and flume for the purpose of working a portion of the river bed below. The construction of the mill for the purpose of testing the quartz leads of the vicinity was also continued.

Prospectors—A certain amount of desultory washing was also carried on by individual prospectors.

Ditton district.—In the Ditton district in Compton county, a small amount of preliminary prospecting work was done by the Ditton Gold Mining Company.

Dudswell.—It was reported that gold was found on a small stream in Dudswell Township, where a little prospecting was done during the year.

Ontario.

ONTARIO.

Mining for the precious metals in this province was confined to the gold mining in the Madoc and Marmora region in the east, the work done at the Ophir Mine in East Algoma, and the Rat Portage district in the west.

In the silver mining district south-west of Port Arthur, nothing was done other than a little prospecting work, all the large mines of former years being shut down.

Peterboro' County.

PRECIOUS METALS.

Discovery and development.

Ontario.

In Peterboro' county the Belmont mine operated with a force of twelve men for eight months on the east half of lot 20 in Concession I., of the Township of Belmont. The work consisted largely of prospecting work and tests of ore with the Crawford mill erected on the property. Reports of experts, who examined the property in the interest of parties desiring to bond it, seem to show the existence of a number of fissure veins, carrying free gold and auriferous sulphurets in a quartz gange. According to Mr. Brumell, who visited the place, the works consist of three shafts and two open cuts. The main shaft is said to be 132 feet deep ; the Strickland shaft, the most easterly, thirty feet deep, whilst the O'Neill, on a cross vein to the south of the Strickland, is about thirty-five feet deep. The machinery in connection with the mine consists of one Blake crusher with feeder ; two Crawford mills and plates ; engine and boiler.

At the Ledyard gold mine on the east half of lot 19, concession I., Belmont township, a small force of from five to ten men was engaged for about seven months of the year. Mr. Ledyard informs us that a sample lot of three tons of the ore was shipped to Messrs. Ricketts & Banks of New York, which gave them an assay result of $27.60 per ton, and by actual mill test yielded $25.40 per ton. He further states that several hundred tons of gold bearing ore are in the dump obtained from the shaft and from other openings which have been made on the vein. One vein from four to six feet wide, it is claimed, has been proved for 200 yards. It is intended to erect a stamp mill on the ground to treat the ore. Mr. Brumell, when visiting this property for the Survey, found the workings to consist of an open cut about forty feet long, in the end of which a shaft had been sunk thirty-five feet on the vein which measured six feet in width on the surface, striking N. 65° E, dipping to the south at an angle of 60°. The ore consists of quartz carrying pyrites with a small proportion of mispickel and free gold. The latter occurs more abundantly in the rotten honeycombed quartz and "gossan" on the surface.

Hastings County.

Mr. Brumell during his visit gleaned the following information regarding operations in this district :

The Crescent Gold Mining Company own and, until quite recently, operated the Gladstone and Fiegle properties, consisting respectively of lots 17 and 16, range XI, Marmora. The operations consist of several open cuts and strippings and of two shafts ninety and sixty feet

PRECIOUS METALS.

Discovery and development.

Ontario.

deep respectively, which cut diagonally across the several stringers and leaders which go to make up the mass of vein matter constituting the main ore body. The various veins opened up are said to have afforded some very rich stuff, more especially in the rotten and weathered portions at the surface. The mill and plant in connection with the mine are in first-class condition, and include one Baker crusher, ten stamps, two automatic feeds, two amalgamating plates and one improved Frue vanner engine and boiler.

In Marmora village, the Hastings Mining and Reduction Company of Toronto, have erected and are now running a small custom mill, and state that very good results are being obtained. The mill is run by water-power and contains one Blake crusher, one Griffin mill, one Walker and Carter roaster, one amalgamator, three collecting pans, one settling pan, two arsenic condensers and drying floor.

This company worked the Pearce Mine on lot 8, concession VIII. of Marmora, for a short time on option, and took out a number of tons of mispickel ore which they treated at their own mill in Marmora.

At the Demarse mine on lot 24, concession V., of Marmora, no work was done.

Eastern Algoma.

The chief operations carried on in the Algoma district were those of the Creighton Gold Mining Company at their mine in Creighton township, and of the Ophir Mining Company at their mine in Galbraith township.

The Creighton mine is situated on lot 11 in concessions IV. and V. of the township of the same name. Exploratory work has been carried on here for some two years on quartz veins from which assays have been obtained giving returns of gold. One vein has been followed down to a depth of 160 feet by means of a shaft from which, at the respective depths of 80 and 130 feet, levels have been driven for twelve and twenty-five feet. A mill having a capacity of twenty tons per day has been erected. The ore is crushed by a Dodge crusher and treated in a Crawford mill. Besides the machinery for treating the ore, an engine-house attached to the mill contains a 100 horse-power boiler to work the hoisting engine, drill and mill machinery.

At the Gordon Lake location in the vicinity of the last described mine, some surface work was done to test a similar quartz vein.

Thunder Bay District.

Some prospecting work was done on veins in the gold bearing areas of rocks west of Port Arthur near Ignace and Taché Station on the

Canadian Pacific railway. Near Lake Shebandowan, Mr. O. Daunais, the well known explorer. and his associates acquired a property to which they were engaged in cutting a road with a view to commencing development work.

PRECIOUS METALS.

Discovery and development.

Ontario.

On location 395P, half a mile south of Rossland Station on the Canadian Pacific railway, work was done by Port Arthur capitalists under the superintendence of Mr. Peter McKellar. A number of surface cross cuts were made and a 50-foot shaft was sunk on the vein. This employed a force of five men for about six months and resulted in the mining of 75 tons of ore now on the dump.

Lake of the Woods.

In this district development work was done at the Sultana, Gold Hill, Rajah, Black Jack and Bad mines and others. At the end of the year 1893, the chief developments were as below given, according to news received from a correspondent, who writes as follows :—

Black Jack Mine.—Shaft down 80 feet on the vein with a drift 65 feet in length at 60 feet from the surface. The vein matter is said to average \$8 to \$10 per ton with occasional lenses of very high grade ore, some of which has assayed as high as \$1,500 per ton. The plant in January consisted of two Crawford mills with Blake crusher, engine and boiler and necessary fittings. The mill did not, however, prove successful. A force of only four men was retained during the whole of the summer and but little development was done beyond sinking a shaft 25 feet upon another vein on the property. Towards the end of the year a two drill Rand compressor and a 16 h.p. Bacon hoist were put in, whilst the shaft was straightened and retimbered and a substantial frame-shaft house erected. About 25 men were employed on the property in the fall.

Gold Hill.—Considerable money was spent at this mine experimenting with the Leeds process for the extraction of gold from the ore, but during the year this was abandoned and a ten stamp mill of the old slow-drop Colorado pattern was erected, and is doing excellent work. Two shafts are being worked on the Pebble and Ada G. veins respectively, and it is proposed to put in a compressor and hoisting plant.

The Sultana Mine.—Last fall a ten stamp mill of the regular fast drop pattern, with 12-foot copper tables, Blake crusher and Frue vanners, was erected at this point under the superintendence of Mr. Chas. Brant, M.E. This, during last summer, was supplemented by a small cyanide plant which is said not to have proved very successful. A shaft was being sunk on the vein, which had attained a depth of about

PRECIOUS METALS.

Discovery and development.

70 feet by the end of the year, and drifts were being driven along the course of the vein on either side of it. The vein is about five feet in width and is said to yield free milling gold to the extent of about $20 per ton. It is proposed to put in a compressor and hoisting plant at an early date.

Ontario.

The Bad Mine.—This is situated about a mile south of Rossland station on the Canadian Pacific railway, and at this point the Rat Portage Mining and Reduction Company are sinking a shaft. At a depth of 20 feet it is said the vein has improved both in width and gold contents, and shows about 5 feet wide of $40 ore. It is proposed to develop the property as rapidly as possible and, if developments are satisfactory, it is the intention of the company to refit their reduction works at Rat Portage with stamps.

The El Divir Mine lies north of Rossland and after a shaft had been sunk to a depth of 95 feet it was abandoned for the present.

The Treasure Mine is situated south of Rossland and has also been abandoned for the present, after a 65 feet shaft had been sunk on the vein.

It is stated that both the foregoing show good ore at bottom of the shafts.

Rainy River District.

Attention has been directed to this district by reported discoveries of gold bearing veins in the belt of Huronian rocks which crosses the lake and runs up the valley of the Seine River. It is reported that numerous veins have been located, both on the American and Canadian sides and extensive work is expected for next year.

North-west Territories.

NORTH-WEST TERRITORIES, &c.

Saskatchewan River.

Washing for gold in the bed of the Saskatchewan River was continued as in past years. From the nature of the operations no very precise data are available, but they may be said to extend from about 80 miles above Fort Saskatchewan to about 125 miles below. The number of miners has been estimated at about 25.

Yukon District.

Considerable work has been done in this section of country in continuation of that done in previous years. It has been found impossible to get exact details, so that it can only be stated that a large number of prospectors have been at work washing gold from the gravels of various tributaries of the Yukon River in the vicinity of its crossing of the boundary line between Alaska and Canada. As

PRECIOUS METALS.

Discovery and development in British Columbia.

the exact position of this line is as yet undetermined, there is no means of deciding exactly how much of the gold resulting from these operations has been obtained on Canadian territory. The figures adopted in this report, however, are based upon careful estimates of parties familiar with the district, and the operations carried on. The chief mining done has been on Forty-mile Creek with its tributaries Franklin, Nugget and Cañon Gulches and on Sixty-mile Creek, especially on its newly discovered tributary Miller Creek. The district is very difficult of access, the shorter but more difficult route being overland by trail through the Chilcat Pass in the mountains and thence by the Lewes River; the longer by steamer up the Yukon River. There is a small mining town at Forty-mile Creek where many of the miners make their headquarters when they stay over a winter in the country. Owing to the time and expense of getting into the country, this is said to be the only profitable course to pursue. It is estimated that a man can board himself living in his own tent or cabin for $1.50 per day, and that it takes about $400, including everything, for a man to provide himself for a season. The working season is about from the middle of May to the middle of September.

Mr. Wm. Ogilvie of the Dominion Topographical Survey, kindly furnishes the following data regarding operations in the Yukon country:

	Number of Men.		Total Gold Produced. 1893.		
ALASKA—					
Franklin Gulch......	30				
Scattering	15				
		— 45			
*LOCALITY DOUBTFUL—					
Miller Creek........	100		$90,000	to	$100,000
Davis' Gulch........	50		30,000	"	35,000
		—150	120,000		135,000
CANADA—					
Stewart River........	30		15,000	"	20,000
Pelly River..........	30		15,000	"	20,000
Scattering	25		12,000	"	15,000
		— 85			
		280			
Canada—Total, say..........			$42,000	"	$ 55,000
Doubtful " "			120,000	"	135,000
			$162,000	to	$190,000

*Miller Creek and Davis Gulch are tributaries to Sixty-mile Creek, but it cannot at present be stated whether they are in Canada or not.

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The details of mining for the precious metals will be found in the report of the Minister of Mines for the province, the main features of which are summarised below.

The amount of gold obtained by placer mining is rather less than in 1892, but the total yield is greater owing to the returns of some of the quartz claims in the Yale and West Kootenay districts.

The anticipations formed in 1892 of an increased output from hydraulic workings have not been realized, owing to the development work on the majority of the claims not having reached the stage when results could be expected, whilst in other cases operations have been hindered by an insufficient supply of water. This branch of placer mining is yearly attracting more attention throughout the province and the amount of capital already invested and to be laid out during the coming season, more particularly in working the bench lands in the vicinity of the Fraser river and its tributaries, is very considerable.

Interest is also being taken in the beds of the Fraser and Thompson rivers with a view to dredging, and judging from the number of applications for leases for the purpose a serious attempt will be made to prove the worth of the gold hidden in the beds of these rivers. Special machinery for dredging is in course of construction at different places on the Fraser.

Cariboo District.—(From the Reports of Messrs. Bowron and Stephenson.)

The operations in this district consisted largely of prospecting for deep ground in the vicinity of the previously worked shallow placer deposits and in the acquirement by strong companies of ground for hydraulicing and steps taken by them towards installing extensive plants for this purpose.

The two principal hydraulic companies are the Horsefly Hydraulic Mining Company, located on the Horsefly River, and the Cariboo Hydraulic Company under the same management, operating the old South Fork Company's concessions, and the well known Hop. E. Tong claim near Quesnel Forks, which they acquired from their previous owners in August. The former company employed a force of about 60 men and the latter about 40 men.

Williams Creek.—Examinations were made during the season, of the lower part of this creek for a syndicate of London, England, capitalists, with a view to working it by hydraulic lift. Operations will probably be commenced next year.

Prospecting work was done on the Quesnel River about twenty miles from its mouth by Messrs. Fry, Cameron & Co., testing the value of the gravel hills along its sides. PRECIOUS METALS.

Prospecting work of greater or less extent was also prosecuted on Chisholm Creek, a tributary of Cottonwood River, on Slough Creek; on Shepherd Creek and by the Nason Company on Antler Creek. Also on Keithley, Snowshoe, Harvey and Spanish creeks, and on the north fork of the Quesnel River. The Harper lease on the Horsefly River was not worked much during the season owing to the unusually high water and the damage done thereby to the dam. A party of prospectors were working, however, some 60 miles above this point. Discovery and development in British Columbia.

In addition to the list of paying claims and of those contributing to the gold product of the district as given in last year's report, must be mentioned that of Messrs. Joseph Shaw & Son on Hardscrabble Creek, which has paid handsomely this season and promises equally well for the future.

In quartz mining nothing was done beyond representative work.

The development of the country is retarded by the absence of railway communication. The construction of additional roads and trails is, however, constantly altering this condition, and the completion of the sleigh road from 150 Mile House, on the main stage road, into Horsefly will enable the needs of that part of the country to be better dealt with. The explorations and surveys made by the Government on the Nechacco River and elsewhere show the existence of extensive tracts of agricultural and grazing lands which, when settled, will form an important factor in supplying farm produce to the mining community.

The total output of gold for the season (1893) is, as near as can be ascertained, somewhat greater than last season. This must be regarded as highly satisfactory, as so many white miners have been engaged in opening up new mines and other non-productive works that the Chinese have been much the larger producers.

The estimated gold product of the district for the year is as follows, viz. :—

Barkerville Polling Division,	1st January	to 15th	November..	$73,000
Lightning Creek	"	"	" ..	49,000
Quesnel	"	"	" ..	25,450
Keithley Creek	"	"	" ..	54,550
Estimated product from 15th November to 31st December (say).				8,000
				$210,000

Cassiar District—(From Mr. Porter's Report).

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There is a decrease in the production of gold since last year which is due to the fact that the old creeks are becoming less remunerative every year, although McDame's Creek and its tributaries produced more gold this season than last.

About ten persons worked during the summer on the bars of the Liard River, but were not so successful this year as last owing in a great measure to the fact that the water kept at a high stage for the greater part of the season.

Dease and *Thibert Creeks* have produced less this year than any season since they were discovered for the reasons already stated that they are about worked out, though some of the hill claims may continue to pay a fair return for a time longer.

But little prospecting for new placer ground was undertaken during the year.

Quartz Mining—Eleven mineral claims have been located along the Hyland River on which some prospecting work was done, and several hundred pounds of samples taken out and sent to various points for assay.

The following is an approximate estimate of the gold yield of the district for the year :—

Dease Creek	$ 6,500
Thibert Creek	4,409
McDame's Creek	9,876
Liard River division	1,700
Stickine River division	450
Total	$22,935

Yale—(From Reports of Messrs. Tunstall, Lambly, Dodd & Hunter).

A small amount of washing was done by Chinese in the bed of the Thompson River, and alluvial prospecting was done on Deadman's Creek, resulting in finding coarse gold, and on Criss Creek, a tributary of the same, with but slight result.

"The *Van Winkle Bar Hydraulic Mining Company*, above Lytton, have made two satisfactory wash-ups. This cut is now close to the old channel of the river, where they expect to find the richest pay.

"The *Prince Albert Flat Mining Company*, at Emory, have had a strong force of men at work the past summer making preparations for

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piping. A tunnel has been run in the leasehold at Botanie Creek, and encouraging prospects in coarse gold obtained.

"On *Siwash Creek* the placer mining companies have not met with the success anticipated.

"About twenty-four miles of the bed of the Fraser and Thompson rivers are already under lease for diving and dredging, and applications for over twenty miles more have been forwarded to the Lieutenant-Governor in Council.

"The principal applicants are Captain Finch and partners, with whom is associated Colonel Underwood, of Chicago. These gentlemen have formed a strong company for reclaiming the rich auriferous deposits of the Thompson River by means of a powerful centrifugal pump stationed on a boat, worked in conjunction with several new devices of recent invention and a portable coffer-dam, which is placed in position when needed in a strong current to enable working in still water, and the removal of boulders by a diver, who also has entire control of the apparatus and directs its application with the assistance of submarine electric lights. The gravel is sucked up and deposited in a string of sluice boxes on the boat, where it is washed and the tailings run into the river. Should the results justify the expenditure, it is the intention of the company to build and equip fifteen boats with the requisite machinery for the active prosecution of this new branch of mining, which will employ a number of men."

Mr. Dodd's report gives the following details relating to these important ventures :—

"The dredge is especially designed for use in any part of the river where it is impossible to do remunerative work with the aid of any other appliance hitherto available, and the property it possesses of saving the fine gold is claimed as the secret of its success. The scow is made into eight watertight compartments, is sixty-six feet long by twenty-four feet wide, strongly and substantially built, and draws only twelve inches of water ; everything is under cover and well protected from the exposure of the elements. It is conveniently equipped with every necessary and useful appliance for the skilful handling of auriferous gravel. The powerful steam winch is worked, by suitable gearing, in connection with the other powerful hand winches, which can be worked together or independently, so as to allow of the greatest freedom in moving the dredge to suitable or convenient points of the river.

"One duplex steam pump and one centrifugal pump are used for distributing the auriferous wash-gravel into the rotary amalgamating basin, which is six feet in diameter and ingeniously arranged for the nfusion of gravel from the outlet delivery of the suction pipe. There-

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by the promoters claim the secret of the invention, by rapid rotation of centrifugal motion. Every precaution and advantage evidently is taken for securing, by the matte of quicksilver, which is deposited into the rotary amalgam basin, the finest particle of fine gold. One horizontal engine and one vertical engine, with 70 horse-power boiler, with a powerful telescope pump attaching to a projecting boom, sixteen by eighteen inches thick, and twenty-five feet in length, slightly elevated from the main deck of the scow, with a half-circle sweep of twenty-five feet, are available for raising the auriferous gravel from the bed of the stream.

"One thousand cubic yards can easily be excavated within twenty-four hours, and the suction pipe can be freely handled and adjusted to any suitable place, for operating the auriferous gravel, by one person. The dredging is partly on the principle adopted for sluicing claims, with improved appliances for saving fine gold. The electric lights to be used are of one hundred and twenty (120) candle power, and the intention of the company is to carry on operations night and day, and ten men can manipulate and carry out the necessary work of two shifts. By the electric light the owners of the project claim they can see the operations working at the bed of the river. A trial test of the gold-dredging machinery was made a few days ago which resulted very satisfactorily, Gravel was pumped from thirteen feet below the water, and several gold colours were brought up, demonstrating the fact that gold exists in the river's bed. Since the trial test, the promoters of the scheme are more sanguine than ever of the future success of the undertaking, and Mr. Shahan has applied to the Dominion Government for a patent of the new invention for gold dredging for Canada.

"A new era of gold mining has been inaugurated in the deep waters of the Fraser River, which for hundreds of miles in length can be remuneratively worked. From trials made in other parts of the world, extending over a period of five or six years, it has been found that wash-dirt can be elevated and the gold extracted from it in paying quantities when not more than one grain—say four cents' worth—exists per cubic yard, and I need hardly say that many rivers run through British Columbia which are known to contain very much more valuable pay-dirt.

"*The Prince Albert Flat Hydraulic Gold Mining Company's* claim, held under lease, is situated on the west bank of the Fraser River, near Emory Bar, about four miles west of the town of Yale, and consists of about eighty acres. During the latter portion of last year, extensive preparations were made by the promoters of the company for excavating and cutting through gravel benches, in places from

twenty to thirty feet deep, and equally as wide at the surface, to secure the sides of the cuttings from caving, and interrupting their course of work in diverting the water from the natural course of Emory Creek on to the initial point of operations. The company obtained prospects by panning from several points, which were sufficiently satisfactory to encourage them. A portion of ground contiguous was worked by pioneers in 1858, 1859, and 1860, which yielded $15 to the man per diem. About $8,000 have been expended in the completion of the flume, and on the ditch and steel pipes. The flume is strongly built and well laid, capable of carrying 3,500 inches of water. It is over a mile long, four feet wide, by three feet deep, and everything is in order awaiting the season to open and permit the company to commence early mining operations.

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"*Hill's Bar Flat* is situated on the east bank of the Fraser River, and stretches away in a south-westerly direction for a distance fully a mile and a half. Operations are to be resumed on an extensive scale in the forthcoming spring on the Hill's Bar Flats in a more practical form than the last working. The close proximity of the celebrated Hill's Bar, which yielded such an enormous quantity of gold within a small area, has stimulated the confidence of mining experts, owing to the indications that the continuation of the auriferous channel that made Hill's Bar so rich has permeated through these grounds."

Queen Gold and Silver Mine, Yale Creek.—At this mine considerable development work was done in the past, over 2,500 feet of tunnelling having been driven, intersecting five veins.

Gold Queen Mining Company, Siwash Creek.—Preparatory work was done here in developing the Company's numerous claims on the creek. To communicate with the property a wire cable 400 feet in length was stretched across the Fraser River with a trolley basket capable of transporting passengers, mining material, &c. Judging not only from the gold-bearing nature of the gravels of the creek, but also from the quartz obtained showing free gold, and from favourable assays of specimens of the same, it is believed that the indications are favourable. Some tests made in the company's small mill gave with the imperfect treatment possible $4 per ton free milling gold.

"The property of the *Van Winkle Hydraulic Gold Mining Company* is situated on the west bank of the Fraser River, two miles above the village of Lytton. It consists of five leases, containing some 660 acres.

"The benches rise from 110 to 397 feet above high-water mark of the river. The gravel in the prospecting shafts will run an average of 10 cents to the cubic yard, the gold being of a coarse nature.

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"Leases of 1,000 inches of water from Last Chance Creek, were brought on to the works last summer, and additional leases have been procured for bringing 9,000 (miners) inches of water from Stein Creek, a distance of 3½ miles by flume and ditch, at a cost of $15,000.

"Last summer the mine was opened by running a cut 800 feet through the front bench to tap the old channel, which was accomplished very satisfactorily, and the pit opened out and everything made ready for a continuous mining run in the spring. There is now a double pit capacity, 800 feet of main sluice, and 276 feet of broad sluices extending to the dump, emptying into the Fraser River. The cut at this point is some 750 feet wide, and has a rise of 48 feet from high water mark. The grade of main sluice is 7 inches to the box of 12 feet. The company use two No. 6 monitors, with a head of 377 feet. Last summer in opening the mine the company piped 350,000 cubic yards, and found the duty of the miner's inch, 4 cubic yards, at a cost of 2·8 cents per cubic yard, they obtained $3,800 worth of gold from the sluices during the process of opening the mine, which is considered very satisfactory in the preliminary workings of a cut of 800 feet. Eighteen to twenty hands were employed last summer, and this year the company expect to employ 13 to 15 hands all told. The prospects for the coming season are very bright and afford reason to expect good results."

In the Osoyoos subdivision of the Yale district some important work was done in developing and working quartz veins in the Fairview and Boundary Creek camps.

In placer mining, much prospecting for placer ground was done on Rock Creek and about $4,500 of gold taken out. Productive work was also prosecuted on Cedar Creek, a tributary of the Kettle River; on Boundary Creek and on Cherry Creek. Siwash and Mission creeks are virtually abandoned. The total amount of placer gold produced from the workings on the above mentioned creeks was $9,650, Rock and Cherry creeks being the principal producers.

Fairview Camp.—The result of the work done at this camp has an important bearing on the future of the district, illustrating as it does the possibility of successfully operating the gold bearing quartz veins there found, as shown by the satisfactory results of actual mill tests and not being dependent upon the doubtful data of the assays of specimens.

The following extracts from the report of Mr. Lambly, the Government Gold Commissioner for the district, will fully illustrate these points :—

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"Development work has been pushed with vigour in this camp during the past season; the satisfactory returns from the ore milled by the Strathyre Mining Company's mill; from a number of the principal claims, notably the Wide West, Brown Bear, Morning Star, and Victoria, being an incentive to the owners of claims adjacent to these properties to prosecute work on their claims with more than usual ardour; and I am pleased to be able to state, in many instances with marked success. A number of locations have been made on the range of mountains between the camp and Keremeos, on most of which the locators have done the annual assessment work, showing their confidence in these new discoveries."

The following information concerning the *Strathyre Mining Company (Limited)*, and list of assays and mill tests of ore from different mines in the camp, was kindly furnished to me by Mr. George Attwood, F.G.S. :—

The Strathyre Mining Company (Limited), Dominion charter; original capital stock, $125,000, lately increased by consent of the shareholders to $500,000.

"Directors.—Duncan McIntyre, President; Sir Charles Tupper, Bart; T. G. Shaugnessy; Edmund D. Reynolds, Managing Director. Consulting Engineer, Geo. Attwood, F.G.S., Assoc. M. Inst. C.E.

"Mining properties acquired by the company are: "The Rattler," "The Brown Bear," "The Wide West," "The Wynn M.", "The Ontario," and the Rattler mill site and water right.

"*The Rattler.*—Work on this claim has been confined to taking out about twenty tons of ore from the old shaft.

"*The Brown Bear.*—On this claim work has been pushed with vigour during the summer; a cross-cut tunnel has been driven some three hundred feet in length, and four veins intersected, the largest vein being over six feet in width. About one hundred tons of ore have been worked in the mill from one of the tunnel veins, and the yield in free gold and concentrates was about eight dollars per ton. Work on the tunnel is still going on, in anticipation of finding the main vein, which shows on the surface. The tunnel cuts the veins from 80 to 165 feet vertically below the surface. About ten men have been employed steadily during the summer on surface explorations and in the tunnel. The tunnel is about seven feet in height by five feet in width at the base, and it is supplied with a steel boiler-plate car, which runs on steel rails, connecting the mine with ore bin of fifty tons capacity.

"*The Wide West.*—The old tunnel on this claim has been extended to a length of 360 feet, and a shaft 4 x 5 feet clear of timbers sunk to a depth of 100 feet below the tunnel level, and an air-raise has been made

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from the tunnel to the surface. From ten to twenty men have been constantly employed on this mine during the summer, and suitable buildings have been erected for their accommodation.

"*The Wynn M.*—Work on this claim has been confined to sinking a new shaft thirty feet in depth; some very fine specimens of rock showing free gold was taken out.

"*The Ontario.*—Two trial pits were sunk on this claim during the ummer, and a drift run to connect them.

"*Strathyre Quartz Mill.*—A complete battery of ten rotary gravitation stamps, weighing about 750 lbs. each, has been put in place. The mortar boxes on which the stamps work, weighing over 6,000 lbs. each, and the foundations of the same have been made of timbers twenty feet long, squaring thirty inches, placed on end. Copper plates galvanized with mercury are used to collect the free gold, and the quantity employed is nearly double that of ordinary gold mills. The stamps are fed by a self-feeding apparatus called the Challenge feeder, and the rock after being broken, weighed and dumped into the large bins, is not again handled, as the system is automatic. The copper plates save most of the free gold, and the sands after passing over them are treated in six Frue Vanners, which collect the fine gold and amalgam which has escaped the copper plates.

"The present milling process has been found to be satisfactory, as the tailings when carefully saved and evaporated, and then assayed, show, from numerous assays, an average loss of twenty-five cents per ton in gold. The expenditure incurred by the company in the enterprise thus far is over $112,000, for purchase of property, development of their mines, construction of the mill and assay office, dwelling and boarding houses, and the construction of branch roads.

"*The Morning Star.*—The enterprising owners of this property, Messrs. Mangott, McEachern & Lefevre, have taken out and milled at the Strathyre Mining Co.'s mill during the season, 385 tons of ore, besides doing a large amount of surface prospecting."

Victoria Mine.—Besides other work done, the owners of this mine have taken out and milled ore as per statement below.

Mill Tests.—The following table has been arranged from data given in the report and illustrates the results of practical tests of the ores of this camp.

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MILL TESTS

OF GOLD ORES OF FAIRVIEW CAMP.

STRATHYRE MILL.

Tons of ore milled.	Weight of bar, oz.	Gold, fine.	Silver, fine.	Valuegold per ounce.	Value of gold in bar.	Tons of concentrates.	Gold per ton, oz.	Value of gold in concentrates.	Free gold per ton.	—
									$	
....	58·32	692·5	284	$14·336	$ 835·72	....	....	....	....	Wide West Ore.
50	32·50	768	209·5	15·876	515·77	1	3·68	$ 76·06	10·31	Wide West Ore.
$100\frac{1200}{2000}$	60·00	791	188	16·351	989·25	$1\frac{800}{2000}$	3·88	80·19	....	Wide West Ore.
96	.. . .	....	....	....	1106·78	2	4·31	89·80	11·52	Wide West Ore.
385	92·25 90·20 154·68	728·5 720 728	252·5 241 237	15·059 14·883 15·05	1389·19 1342·17 2327·93	2	8·99	185·82	Average 13·14	Morning Star.

VICTORIA MILL.

Tons of ore milled.	Weight of bar, oz.	Gold, fine.	Silver, fine.	Valuegold per ounce.	Value of gold in bar.	Tons of concentrates.	Gold per ton, oz.	Value of gold in concentrates.	Free gold per ton.	—
$351\frac{800}{2000}$ $13\frac{1600}{2000}$	67·50 30·52	812	173	16·785 16·78	1132·98 512·12	$0\frac{400}{2000}$	12·15	251·15	.... 37·38	Return in gold and concentrates taking the value of the concentrates at 80% of the assay value = $32.40 per ton. Victoria Mine.

Total ore crushed by this company for season yielded free gold $13,404.

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Other Camps.—On the mountain south of Fairview with one exception nothing but assessment work was done. On *Harris Creek* considerable prospecting work was done on mineral claims, but no details of the results are available. *Camp McKinney*—With the exception of the sinking of a 61 feet air-shaft to connect with the tunnel on the Cariboo claim, nothing but assessment work was done.

Boundary Creek.—On the properties controlled by Mr. Howard E. Walters, of Spokane, Washington, some interesting developments have been made as follows :—

On the *American Boy*, near the Boundary Creek falls, a tunnel was run in 85 feet ; on the *Providence* mine situate about five miles further up the creek from the last mentioned, one shaft is down 70 feet and a second 15 feet ; the *Defiance* claim, which was recorded on 4th September, 1893, is adjacent to the Providence and has a shaft down 20 feet and the *Skylark* mine situate about three miles easterly from the Providence camp, or about half way between that point and the Greenwood camp, was recorded on the 28th July last, since which time two shafts, one of 55 feet and the other of 15 feet, have been sunk. As a result of the above mentioned developments about $34\frac{3}{4}$ tons of ore were produced which was packed out on horses to Grand Prairie, Kettle River, thence by wagon to Marcus, and thence to the smelter at Tacoma. This ore gave a total return of about 11,500 ounces of silver and 37 ounces of gold. The following tabulation gives the details of these statements :—

Name of Mine.	Ore Shipped.		Silver, ounces per ton.	Gold, ounces per ton.	Remarks.
	Tons (2000 lbs.)	Sacks.			
American Boy.........	$2\frac{1400}{2000}$	83	230	1	
Providence	$16\frac{500}{2000}$	500	400	1	Since June.
Defiance......	$2\frac{350}{2000}$	67	560	2	Since 4th Sept.
Skylark	$13\frac{1625}{2000}$	425	268	1	

In the other camps of this district, viz., the Wellington, Greenwood, Summit, Volcano, Mountain, White's and Attwood, little more than assessment work was done.

The necessity for a trunk road between Okanagan and Grand Prairie on Kettle River is greatly felt and the construction of this, together with a branch road for some distance up Boundary Creek, would be of great benefit to the mines.

Similkameen Division.—On Granite Creek the Pogue Company is the only one paying at present. Their tunnel is in over 1,000 feet and is

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still being pushed. On the Tulameen and Similkameen rivers several companies of Chinese have been getting good results. The Tulameen Hydraulic Company have been prospecting the lower end of their ground ; sinking shafts and drifting. The Similkameen Gold Gravels Exploration and Hydraulic Company, whose property is situated on the above river opposite Princetown, have been prospecting their properties with a force of fifteen whites, sinking shafts and drifting.

On a number of the creeks in this division applications for leases have been made for mining ground for the carrying on of hydraulicing operations. On quartz claims in this district, nothing but assessment work was done. The construction of the contemplated wagon-road from Nicola to Granite Creek, to the point reached in the south fork of the Otter Valley, has already proved very beneficial, and will greatly stimulate the settlement of the district opened up, as well as greatly assist in mining developments.

Lillooet District.—The following notes by Mr. Phair, the Government Gold Commissioner at Clinton, taken from the report of the Minister of Mines for the province, gives the main features of the mining activity in this district.

"The quantity of gold mined, which has been reported to me from reliable sources, is valued at $51,376, showing an increase of $11,613 when compared with the previous year's yield, Mr. A. W. Smith, M. P.P., of Lillooet, having purchased $24,616, and Mr. F. W. Foster, of Clinton, $11,060 of it. A large number of leases for hydraulic mining, especially near Lillooet, has been granted during the year, and appli cations for several more have been received.

"The North American hydraulic claim has been bonded for $10,000, a deposit having been paid, and it is the intention to bring water on to the ground from Cayoosh Creek at a cost of about $30,000, the route for which has been surveyed.

"A company of six men has been engaged during the season opening out a hydraulic claim on Bridge River. The Vancouver Company, on Cayoosh Creek, have not taken out as much gold as was expected, owing to the difficulty of meeting with large boulders, which have had to be blasted, but that claim is now open.

"The leases of the Lillooet Hydraulic, North American, and Mina companies have paid better than during the past years.

"Cayoosh Creek, which yielded a rich harvest to many Chinese, is almost abandoned, but undoubtedly it still contains a great deal of gold which cannot be taken out by unskilled miners with the pick and shovel, but, if capital were introduced, the creek could be profitably worked.

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"There is nothing to report as to mineral claims, none of them having been worked to any extent during the year."

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East Kootenay—(From the Report of Mr. Cummins).

"The yield of placer gold this season, has been confined to two creeks, both situated in the Fort Steele Division, and is estimated by Mr. Edwards, the Mining Recorder, as follows :—

Wild Horse Creek	$19,000
Moyie River	700
Total	$19,700

"Mr. Griffith's hyraulic property on Wild Horse Creek, was sold to the East Kootenay Exploration Syndicate, of London. This company placed a considerable amount of new plant, supplied by the Albion Iron Works, of Victoria, on the ground this season, and piped for a time. The results are stated to have been such as to justify working next season on a much larger scale. The hydraulic ground, worked at a profit for many years by Chinese companies, has been bought by Mr. Griffith. It is probable that this ground will also become the property of the syndicate, in which case hydraulic mining, to an important extent, may be looked forward to in the near future on Wild Horse Creek."

Both in this vicinity and in the Donald division applications for leases have been made, having in contemplation extensive hydraulic operations, which will probably be commenced next season.

In quartz mining, whilst there has been a great deal of prospecting in various parts of the district, the commercial depression has had its effect in retarding the acquirement of the capital necessary for the prosecution of large undertakings.

Particulars of the discovery and development work in the various subdistricts and camps are as follows :—

McMurdo Subdistrict.

At the Bobby Burns and International group of gold properties nothing but assessment work was done and only inconsiderable development work on the claims on Cariboo mountain and Cariboo Basin and Copper Creek.

Vermont Creek Subdistrict.

The claims on the south side of this creek have been worked by Messrs. Wells & Pollock, the owners. One hundred tons of ore

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were taken out of the tunnels and stopes and shipped out over a sleigh road to the Columbia River, which shipments would run about 100 ounces in silver with 50 to 60 per cent of lead.

On Spilimichene Mountain, Jubilee Mountain and Horsefly Creek but little work was done.

Thunder Hill Group.—Work proceeded rapidly during the early part of the summer and the previous winter, a force of 45 men being employed. The concentrating works described in last year's report were completed and ran for a short time in the beginning of August, the machinery working very smoothly and well. The works and mine shut down about the middle of August owing, it is understood, to lack of funds. No further developments of importance are reported in the Hughes Range between the Columbia Lake and the vicinity of Wild Horse Creek, though some locations were made.

Wild Horse Creek.—The future prospects of this creek and its vicinity for gold quartz are very encouraging.

" Several prospectors have worked in this direction during the past season, and made some important discoveries. On the south side of the creek, about seven miles above Fort Steele, three claims were located by Messrs. Banks & Young on a strong lead stated to be cropping continuously for over 2,000 feet. The following particulars are derived from a reliable aud disinterested person, after the examination of the ground in the end of October: The width of the ledge varies from 2 feet to $4\frac{1}{2}$ feet. The strike is about east-and-west. It runs through about the centre of a belt of porphyritic rock, about 100 feet wide, the country rock on east side of this belt being quartzite. The ledge cuts the formation very clearly at about 30° and dips into the hill, or south about 45°. There is evidence of the lead becoming more vertical in depth. Picked samples can easily be obtained from the Western or Dardanelles claim showing quantities of free gold, the richest streak being on the hanging wall. The lead is described as having all the characteristics of a true fissure. Up to the end of October, the discoverers had done but little work on the lead, as they had been engaged in building a trail to the claim and putting up a cabin in order to work all the winter.

About three miles further down the creek, but on the opposite side, about 1,500 feet in elevation above the hydraulic properties, a ledge, known for some time, has been prospected by Messrs. Dougherty & Griffith. On the surface the quartz had a very favourable appearance for gold, but nothing could be panned from it, even after sinking a shaft to a depth of 20 feet. From this depth to 30 feet, which had

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been reached when last heard from, most satisfactory results were obtained by panning. So far, they have sunk two pits, one 30 feet deep and one 15 feet. No gold has been found yet in the latter. The pits are about 200 feet apart. The lead appears to strike in a north-westerly and south-easterly direction, but seems on the surface a good deal mixed with the quartzite formation, making it difficult to judge its exact width, which appears to be from 2 feet to 6 feet and possibly more. It is stated that a slate foot-wall has been struck near the bottom of the 30-foot shaft. The owners are sanguine of having a good free milling gold property.

"Another discovery of free gold quartz, near this locality, was made in the latter part of the season, on the front range facing the Kootenay Valley, between what is known as Horse Shoe Cañon and Mouse Creek. Numerous specimens shown me from here contained considerable quantities of free gold, plainly visible without a magnifier, in a copper stained quartz, gray copper being also present. The discoverers stated that the vein could be traced for a considerable distance and ranged in width from about 8 inches to 2 feet. The samples I saw seemed to me to come from the narrower portions of the vein. No work whatever had been done.

"*North Star Mine.*—In last year's report, page 538, a description is given of the discovery of an immense body of steel galena, near the St. Mary's River, about 20 miles north-west of Fort Steele. It is also mentioned that this property had been bonded by Mr. D. D. Mann, of Montreal. The property, consisting of four 1,500 feet square claims, taken up in a square block or nearly so, was purchased by Mr. D. D. Mann and associaties on 1st July last, after having been examined and reported on by Mr. George Attwood, the well-known mining engineer. A considerable amount of development work has been done on the property, both during the currency of the bond and since the purchase was completed. I annex a plan and sections explanatory of this work, which will set forth the work and its results better than any lengthy verbal description. The work extends over about 450 feet of the lode, the greatest depth from the surface reached is 66 feet in the main shaft, sunk at the original discovery cut, where the first body of ore was bared by the discoverers by removing the overlying wash material. The vast body of mineral run through at section 4, where the drift shows solid galena and carbonates for the remarkable width of 65 feet, was opened out until after the purchase of the mine was made. It seems fair to conclude that the work has shown the existence of huge mineral deposits. Though such bodies cannot be looked for in a regular width and richness throughout, there seem very good indications in in this case for their continuance in length and depth.

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"The only regular sampling, the results of which I am aware, gave: Silver, 47·43 oz.; gold, nil; lead, 67·50 %; iron, 6·63%; zinc, 1·90%. Assays of over 85 oz. have been obtained, whilst the carbonate ore appears generally to run somewhat lower in silver. The ore is asserted to be of the very finest quality for smelting.

"The advantageous position of this mine, and neighbouring properties, as regards water communication, can be seen by referring to the annexed general sketch map of the district (see Group 15). The mine is within sixteen miles of the Kootenay River, on which there are at present two steamboats running, one in connection with the Great Northern Railroad at Jennings, the other with the Canadian Pacific at Golden. The country between the mine and the river is easy for wagon road construction. It will also be seen that the located line of the Canadian Pacific Railway's Crow's Nest Pass Railroad passes within about an equal distance from these mines.

One of the most important features regarding the smelting ores of this region, is their proximity on the proposed lines of railroad to the inexhaustible supplies of cokeing coal in the Crow's Nest Pass.

"A number of other locations have been made on the hill on which the North Star is situated, but little or no work has yet been done on these claims so far as I am aware.

"*Sullivan Group of Prospects.*—About 2 to 3 miles to the north of the North Star Mine, on the other side of Mark Creek, outcrops of galena, apparently of a similar nature and size to the North Star, have been located. Great masses of silver galena and iron have here been bared in several places, but sufficient work has not yet been done to enable one to say much about them.

"*Moyie Lake Claims.*—Some important discoveries of silver-bearing galena were made last spring, on the mountains on the east shore of the Upper Moyie Lake. Large outcrops of fine looking galena, 5 to 6 feet in width in some places, occur on the St. Eugene claim, about 1,400 feet above the lake. The little work done here has exposed large quantities of mineral, but has not gone sufficiently deep to show the existence of a lead of a continuous nature. Adjoining the St. Eugene claim, to the north, is the Queen of the Hills' claim. A line of claims extends from here westward down to the lake. A continuous vein is supposed to run through these claims, but sufficient work has not yet been done to determine the fact.

"*Locations at the Head of St. Mary's River.*—On the various forks of the St. Mary's River, no less than 46 mineral claims were located in the early part of the summer. There appears to have been a rush into that locality of prospectors from West Kootenay. Most of these

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locators returned to the Kootenay Lake country, forwarding their records to Fort Steele. I regret to say that it has not been possible for me to obtain information as to the importance of these discoveries. I am, however indebted to Mr. Sandilands, of Ainsworth, for some information derived from some of the prospectors. It is stated that the claims on the West and Middle Forks contain large bodies of galena assaying from 26 to 66 oz. in silver, and 65 per cent lead. The leads in some cases carry copper.

"All the discoveries on the South Fork carry copper and silver, assaying 56 oz. silver and 31 per cent copper, and are described as strong ledges 4 to 6 feet in width.

"*Lost Creek, Bull River, and Sand Creek.*—Nothing beyond assessment work was done on the claim on Lost Creek this season.

"Promising prospects are reported from both Bull River and Sand Creek. The average of 5 assays from the galena and grey copper leads, about half a mile above the bridge over Bull River Cañon gave: silver, 76 oz.; gold, $21; copper, 22 per cent.

"A large lead containing copper-glance and carbonates, was located on Sand Creek. There appears to be plenty of mineral in the lead, but the grade of the ore at the surface is not high.

"A number of claims are stated to have been located near the International Boundary Line to the east of the Kootenay River. These claims have been recorded in the state of Montana. It is, however, considered by some of the residents on Tobacco Plains, that these claims are really on the British Columbia side of the line.

"*Kimbasket Lake* is situated in the Donald Mining Division, to the north of the Canadian Pacific Railway about 35 miles down the Columbia from Beaver, the nearest point on the railway. A trail has been cut northward from Donald by the government, with a view to giving access to this region, which now reaches as far as the lower end of Kimbasket Lake. The country affords favourable indications for mineral and placer gold, and has tracts of very fine timber. It is satisfactory to find that prospectors are giving some attention to this region."

West Kootenay—(Reports of Messrs. N. Fitzstubbs, R. H. Kemp, M. E., and J. H. Kellie, M.P.P.).

The following condensed statement of shipments from the Kaslo-Slocan, Ainsworth and Nelson districts which is, according to the report, " taken from Customs returns, will give an idea of present out-

put of ore under very unfavourable circumstances as regards freights." The period covered is the six weeks between December 22nd, 1892, and February 8th, 1893, and the average value of the ore is taken at $130 per ton.

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Mine.	Shipments—Tons.	Value.
Washington	574	
Noble Five	174	
Dardanelles	71	
Reco	20	
Mountain Chief	308	
Northern Belle	260	
Freddie Lee	107½	
Surprise	87	
Antelope	43½	
No. 1 (Ainsworth)	14½	
Kaslo-Sampler	58	
Mile Point	11½	
Big Boulder	40	
Hall Mines (Nelson)	120	
	1,889	$245,570

" The figures, though satisfactory, cannot be taken into account in computing the probable output of the Slocan. All the properties are doing development work chiefly. When they are put in shape for mining on the proper scale the output can be then computed ; at present it can only be surmised.

"There are upwards of 400 men in the Slocan and between Kaslo and New Denver, who are employed, either directly or indirectly, in connection with the mines, and when the dangers of snow slides are passed there will be hundreds more. Without a single exception of note every mine in the Slocan has improved as it has been developed, the veins becoming stronger as they went deeper."

The information pertaining to this district contained in the report of the Minister of Mines for the Province will be found in a summarized form in the following tables :

Name of Claim or Mine.	Force employed.	Mining Developments. — Shafts.	Mining Developments. — Tunnels, Drifts, Winzes, &c.	Mining Plant.
				Nelson
Toad Mountain Camp.				
Silver King Group....	45	....	....	....
Dandy............ ..	..	....	[600 feet.] The adit cross cuts the vein at 100 feet in depth and runs on it for 150 feet, showing 4 to 6 feet vein well mineralised. Vein exposed on surface with a width of 10 to 50 feet in four places and traced to the Silver King.	....
Other claims.....	..	....	....	....
Poorman Camp..........	..	....	....	....
Poorman Mine........	..	....	....	....
Majestic Claim.......	..	....	Development work done........	....
White Water Claim...	..	....	Idle during the year..	....
Salmon River Camp......	..	....	....	....
Several claims lately located.	..	....	....	....
Placer Diggings.				
Hall Creek..........	..	....	But little work done during the season.	....
Salmon River.........	..	....	Twenty-one leases taken up. Active operations; principally developmental.	....
Pend d'Oreille River..	..	....		....
				Trail Creek
			Thirty-three locations taken up and eleven	
Le Roi Mine..........	30	Depth increased 100 feet.	Levels from bottom of the shaft 70 feet each way on the vein.	Hoisting machinery shipped to mine.
War Eagle Mine	..	....	....	....
Nickel Plate Mine....	..	50 feet deep.........	Work progressing....	....
Josie Claim...... ...	..	....	....	....

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.	*Ore Mined.		*Ore Shipments, Particulars of.		Remarks.
		Tons.	Contents or Value.	Tons.	Contents or Value.	
Subdivision.						
....	....	....	....	....	....	Said to have been sold for $1,000,000 ; ore shipped to Swansea, England
....	Average reported gold $4 per ton.	....	....	....	....	An extension of the Silver King Group.
....	....	....	....	....	....	Not worked on account of financial stringency.
....	....	....	....	....	....	Five or six miles S.-W. of Nelson.
0-stamp mill	....	....	....	....	....	
....	....	....	....	....	....	A few miles W. of Poorman.
....	....	....	....	....	....	On Rover Creek.
....	Reported as similar to Toad Mountain.	....	....	....	....	About 20 miles S. of Nelson and near the Nelson and Fort Shepherd Railway.
....	....	....	....	....	....	....
....	....	....	....	....	$750	
....	....	....	....	....	....	
....	....	....	....	....	....	

Subdivision.

transfers made of placer property.

....	$60 per ton in gold.	....	....	250	....	Bottom levels show faces of ore of unknown width.
....	....	....	....	....	....	Recent operations said to show continuous body of ore 8 feet wide similar to that at Le Roi mine. About $10,000 said to have been expended to date.
....	....	....	$150 per ton.	....	$150	One vein 18 inches wide and pyritic.
....	....	....	....	Some.......	....	$4,000 spent developing 7 feet vein of pyritic ore.

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine.	Force employed.	Mining Developments.		Mining Plant.
		Shafts.	Tunnels, Drifts, Winzes, &c.	
				Trail Creek
Mountain View.....	..	....	....	....
Cliff Claim............	..	....	Vein traced whole length of claim. Much surface work done.	....
O. K. Mine..........	..	....	Tunnel extended 100 feet. Up-rise of 70 feet made.	....
Other claims..........	..	....	Only slightly developed........	....
				Ainsworth
Number One Mine......	20	1200 feet of shafts, tunnels, &c.	....	....
Mile Point Mine........	6	....	Two tunnels, each of 100 feet in length.	....
Sky Line Mine..........	..	....	Much development already done.	....
Little Phil and Little Donald.	..	....	Joint tunnel 75 feet long run on the dividing line shows 8 feet vein of galena.	....
Budweiser..............	..	Shows 4 foot vein...	....	....
Bobtail; Schafer and Jay Gould Claim.	..	....	400 feet of tunnelling through hard rock.	....
Highland................	..	....	....	....
Highlander............	..	....	....	....
Charleston..............	..	....	....	....
Bluebell..............	..	....	Idle during year..............	....
Rand, Turn of Luck and Baker's Fifth Claim.	..	....	....	....

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Subdivision—Continued.

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined. Tons.	Ore Mined. Contents or Value.	*Ore Shipments, Particulars of. Tons.	*Ore Shipments, Particulars of. Contents or Value.	Remarks.
....	....	....	....	....	About $25 per ton in gold.	Vein 30 feet wide showing for 200 feet.
....	....	....	....	....	....	On the same vein as last.
....	....	250	....	....	....	The three owners, by means of a hand mortar alone, extracted $4000 in one week in September.
....	....	....	....	....	....	Show encouraging prospects.

Subdivision.

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined. Tons.	Ore Mined. Contents or Value.	*Ore Shipments, Particulars of. Tons.	*Ore Shipments, Particulars of. Contents or Value.	Remarks.
50 ton concentrator erected and ready to run. Expect to concentrate 5 tons ore to 1 of concentrate.	....	4,000	Concentrating ore.	85	60 to 275 oz silver per ton.	....
....	Ore said to contain ruby and native silver, assaying 80 to 3,000 oz. per ton silver and 30 per cent lead.	....	....	....	....	One mile S. of Ainsworth and only about 400 yards from Kootenay Lake shore.
....	....	....	....	....	....	Idle this year.
....	80 oz. silver ; 75 per cent lead.	....	....	....	....	Adjacent claims; situated on the Government wagon road about 1½ miles S. of Ainsworth.
....	....	....	....	....	....	3 miles from Ainsworth on Woodberry creek.
....	....	....	....	....	....	S. of Ainsworth 1½ miles on L. Kootenay. Schafer Gold and Silver Mining Co. of Seattle.
....	Silver 50 to 75 oz.	....	....	....	....	Idle.
....	As high as 180 oz. of silver and 30 per cent lead.	....	....	....	....	
....	95 oz. silver ; 30 per cent lead.	....	....	....	....	On Government wagon road.
....	....	....	....	....	....	On E. shore of Kootenay Lake.
....	....	....	....	....	....	On Woodberry creek. Kootenay Mining and Development Co.

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine.	Force employed.	Mining Developments. Shafts.	Mining Developments. Tunnels, Drifts, Winzes, &c.	Mining Plant.
				Kaslo
Wellington..	12	....	Diamond drill used but ground too seamy.	Diamond drill...
Whitewater Claim.......	..	....	....	....
Montezuma and Mexico.	..	....	X-cut tunnel, 70 feet long, cuts vein at 40 feet depth and a drift run 40 feet on the vein shows it to be 1 to 4 feet in width.	....
Silver Glance...........	..	....	....	....
Beaver, Lone Star and Silver Tip.	..	....	Being developed by tunnels....	....
Eureka, Yosemite, Homestake, Scottish Chief and Parrot.		644 feet of shafts.	150 feet of tunnelling and 60 feet of open cuts. Ore streak 16 to 30 inches.	....
Echo Claim.............	..	....	Galena pay streak 6 to 12 inches; 25 feet tunnel.	....
Northern Belle........	14	....	Two tunnels, 150 and 200 feet...	....
Virginia................	10	....	....	....
Beaver.	..	....	....	....
Mountain Dew..........	..	....	4 feet of ore in upper tunnel....	....
Silver Tip.........	..	....	....	....
Brennand Group.......	..	....	Idle.........................	....
Lucky Boy.............	..	....	....	....
				Slocan
Slocan Star Group...... (Slocan Star, Slocan King, Jennie and Silversmith Claim.)	18	....	Systematic development work carried on. Three long X-cut tunnels tapping vein at different levels connected by winzes. Working tunnel 140 feet long to hanging wall, cuts vein at 100 feet depth with drifts on hanging and foot walls.	....
Washington Mine.......	36	....	Development work continuous since opening of mine.	....
Bluebird..	12	....	....	....
Noble Five Group......	15	....	Three tunnels aggregating 600 feet; vein 2 to 6 feet thick.	....
Recall..............	8	....	Developing........	....
Mountain Chief.........	16	....	Four tunnels on vein. Stoping, in all. Vein 2 to 6 feet wide with galena pay streak 1 to 3 feet wide.	....

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined. Tons.	Ore Mined. Contents or Value.	*Ore Shipments, Particulars of. Tons.	*Ore Shipments, Particulars of. Contents or Value.	Remarks.
Subdistrict.						
....	....	....	..... .	100	High grade..	
....	....	....	....	7	$900	
....	80 oz. silver; 60 per cent lead.	....	....	....	....	Idle.
....	Said to assay as high as 1,000 oz. per ton.	....	.. ..	....	....	5 miles from any trail, &c.
....	....	....	....	None so far.	....	
....	125 oz. silver; 77 per cent lead.	....	....	....	....	
....	As high as 327 oz. silver.	....	....	....	....	
....	....	600	....	..... .	....	} White Water Basin.
.. . .	....	....	..... .	....	....	
....	....	50 to 60	....	....	....	
....	Silver 26 to 204 oz.	....	....	....	....	
....	....	....	.... .	....	....	
.. ..	....	....	....	....	....	
....	High grade.....	....	....	 20	....	
Subdivision.						
....	....	At mine 300; 150 at Three Forks.	....	... .	....	Vein in working tunnel 50 feet between walls all shipping and concentrating ore. Ore in drift on foot-wall mixed and in drift on hanging wall 12 feet of solid clean galena.
....	....	....	....	560 Previous to acquirement by present company.	....	
....	....	....	....	300	144 oz. silver; 71 per cent lead.	
....	....	.. ....	....	350 Shipping daily.	150 oz. silver; 69 per cent lead.	
....	.... Ore carries native silver.	 1,000	... .	.. . . Continual shipments.	.... 130 oz. silver; 70 per cent lead.	One mile and a half from New Denver.

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine	Force employed.	Mining Developments. Shafts.	Mining Developments. Tunnels, Drifts, Winces, &c.	Mining Plant.
				Slocan.
Alpha..................	..	....	Contract let for tunnel.........	....
Dardanelles Group .. .. (Dardanelles, Antelope, Buffalo, Okanagan, Diamond Cross, Hidden Treasure and Caribou Claims.)	25	Flat incline shaft 200 feet making bottom of ditto 100 feet vertically.	....	Steam hoist and pump. Further mining plant required owing to heavy water.
Lucky, Jim, Roadley and St. George Claims.	10	....	Tunnels and X-cuts aggregating 500 lineal feet testing vein to depth of 80 feet from surface.	....
Ruecau Group .... (Ruecau, Texas, New Denver, Ephraim and Clifton.)	10	....	Average width of vein 10 feet. Pay streak 18 inches to 8 feet.	....
Grey Copper..........	..	....	Vein 3 feet wide. Ore streak showing 1 foot wide for 200 feet.	....
Payne Groupe.......... (Payne, Maid of Erin, Mountain Chief and Two Jacks.)	8	Five openings from 6 to 20 feet in depth.	40 feet tunnel on Maid of Erin. 100 feet tunnel on Mountain Chief which cuts the vein at a depth at 100 feet.	....
			Vein 8 inches to 4 feet wide with ore streak 6 to 30 inches.	....
Queen Bess..........	..	Shaft 40 feet deep...	Vein shows in places $8\frac{1}{2}$ feet of solid galena. Parallel vein carries galena and "carbonates." 300 feet tunnel cuts vein at 65 feet in depth.	....
Northern Belle Group... (Northern Belle, Dubliu Queen, Kootenay Star and Ophir.	24	....	Two adit tunnels each 250 feet in length and one 15 feet with connecting winzes. Lode from 6 to 12 feet wide of concentrating ore with chutes of clean shipping ore from 18 to 42 inches thick.	....
Freddie Lee..........	8	....	About 2000 linear feet of development made. Vein irregular; ore streak sometimes widens out to 3 feet.	....
Greenhorn............	..	....	Vein traced 1500 feet; 3 feet solid galena.	....
Alamo Group.......... (Alamo, Twin L. and Ivy L. Claims.)	8	....	Vein 3 to 5 feet in width. Ore galena and carbonates. Two tunnels 250 and 165 feet in length.	....
Young Dominion......	..	....	No information to hand........	....
Idaho and St. John Claims	10	....	One tunnel 300 feet long from which 3 cross cuts from 20 to 40 feet long. Another tunnel 60 feet long and 150 feet of lineal development. Veins 5 to 6 feet wide with pay streak $2\frac{1}{2}$ feet solid in places. Ore galena and "grey copper."	....

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined.		*Ore Shipments, Particulars of.		Remarks.
		Tons.	Contents or Value.	Tons.	Contents or Value.	

Subdivision—Continued.

....	....	....	....	....	....	
....	....	....	....	50	99 oz. silver; 51 per cent lead.	Freight charges 10c. per lb. over the 4 miles of trail to the mine.
				150	248 to 322 oz. silver; 26 to 30 per cent lead.	
....	....	....	....	50 to 60	67 oz. silver; 60 per cent lead.	
....	....	....	....	40	167 to 671 oz. silver; 67 per cent lead.	
....	145 to 150 oz. silver and 72 per cent of lead.	....	....	....	....	
....	....	....	....	100	225 oz. silver: and 70 per cent lead.	
....	....	....	....	....	....	
....	....	50	....	....	....	S. side of Idaho basin.
....	....	....	....	600 since June 1.	100 oz. silver; 80 per cent lead per ton.	
....	....	100	....	558	120 oz. silver; 70 per cent lead.	
....	100 oz. silver; 60 per cent lead.	....	....	....	....	Near the Freddie Lee.
....	Ore assays run high.	....	....	1 car load.	....	
....	....	....	....	....	....	Twin L. basin.
....	Ore average 200 oz. silver.	....	....	1 car load.	Valued at $1760.	Two parallel locations 200 feet apart.

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine.	Force employed.	Mining Developments.		Mining Plant.
		Shafts.	Tunnels, Drifts, Winzes, &c.	
				Slocan
Chamber's Group........ (Chambers, Wellington, Eureka and Jay Gould.)	4	....	300 feet development work done. Vein 80 feet between walls. Concentrating ore with pay streaks of pure galena.	....
Best Mine..	..	....	No information available.......	....
Mammoth Mine.......	6	....	....	... .
Egypt Mine...........	5	....	....	... .
Eureka...............	6	....	Two tunnels aggregating 500 feet. Ore struck in the lower one. Vein 20 feet wide.	....
Surprise...............	12	....	....	....
Noonday Group......... (Boulder, Fourth of July and Grey Eagle Claims.)	15	... .	8 feet vein of concentrating ore. 300 feet of tunnelling.	. .. .
Antelope..............	7	... .	....	. ...
Franklin...............	7	....	....	....
Cumberland	6	Shaft 15 feet deep...	Tunnel on vein 132 feet with cross cut 60 feet and drifts on vein from tunnel, one 40 feet and another 70 feet. Ore, galena in quartz. 4 feet vein with pay streak of 14 to 20 inches.	. . ..
Tom Moore and St. Lawrence.	..	....	Vein 5 feet wide.....	....
Great Western..........	..	....	450 feet cross-cut tunnels, &c. Vein $2\frac{1}{2}$ feet wide with 3 to 14 inch pay streak.	....
R. E. Lee..............	..	....	No information to hand........	....
Bon Ton................	..	....	....	....
				Four-Mile
Grady Group......	..	....	....	....
Navigator..............	..	....	3 feet vein with 8 inch pay streak. Parallel vein to Alpha of Grady Group.	....
Vancouver Group...... (Vancouver and Mountain Boomer Claim.)	..	....	Over $4,000 worth of development work.	....
Lorna Doone...........	..	. . ..	18 inches of rich ore...........	....
Reid & Robertson....... (Tenderfoot, Reid, Robertson, N. Star and Cosmopolite Claims.)	5	....	Surface exposure of ore 20 x 1,000 feet. In places $2\frac{1}{2}$ to 4 feet solid ore and the rest concentrating ore.	....

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined.		*Ore Shipments, Particulars of.		Remarks.
		Tons.	Contents or Value.	Tons.	Contents or Value.	

Subdivision—Concluded.

....	120 oz. silver; 60 to 80 per cent lead.	....	....	....	.. ..	
....	....	.. ....	....	....	....	
....	.. ..	....	....	....	....	
....	....	....	....	....	....	
....	169 oz. silver; 70 to 74 per cent lead.	......	....	....	....	
....	....	....	....	100	Rumoured 229 oz. of silver.	
....	.. ..	100	115 oz. silver; 78 to 80 p.c. lead	....	....	
....	....	....	....	. ...	....	
... .	... .	....	....	....	....	
....	. ...	60	... ...	....	....	In Idaho Basin.
....	....	....	....	....	....	N. E. of Great Western.
....	....	30	120 oz. silver; 70 per cent lead.	....	.. ..	
....	....	....	....	....	....	Great Western Group.
.. ..	....	....	....	A few tons..	$300 to $400 per ton.	Jackson Basin.

Creek Camp.

....	....	500	Valued at $125 per ton.	Carload,....	263 oz. silver per ton.	
....	120 oz. silver; 65 per cent lead.	....	....	....	....	Near Alpha of Grady Group.
....	....	....	....	Two carloads.	250 oz. of silver and 40 to 55 per cent lead per ton.	S. side of Four Mile Creek and 4 miles from Silverton town site.
....	....	Several tons.	....	No shipments.	....	Extension of Vancouver.
....	Average sample of croppings 142 oz. silver and 70 per cent lead.	....	....	.. ..	....	

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine.	Force employed.	Mining Developments.		Mining Plant.
		Shafts.	Tunnels, Drifts, Winzes, &c.	

Wilson

A rush to this camp occurred and much prospecting was done, it is said with satisfactory results, but

Eight Mile

Fisher Maiden Group... (Fisher Maiden, Stand-by, and Sixty-three Claims.)	..	....	6 to 7 feet veins with 18 to 20 inches of ore carrying ruby silver and silver glance.	....
Free gold bearing veins reported as discovered.	..	....	....	....

Foot of

Dayton Claim.	..	....	Vein $2\frac{1}{2}$ feet of "dry ore" with 10 inch pay streak.	....

Granite Belt, South

Archie Claim..........	..	....	In Granite belt. Considerable high grade ore said to have been found.	....
Dolly Varden..........	..	....		

Dry Ore

Apart from scattering veins elsewhere in the district yielding this class of ores the discoveries located waters of the N. fork of Carpenter Creek, are particularly noticeable as deposits of "dry ores." process cannot be over-estimated. A number of locations have been made, but so far develop- oz. of silver to the ton.

Silver Glance and Summit Claims.	..	....	Quartz gangue. Pay streak 10 to 20 inches wide.	....
Miner Boy............	5	....	Ore carries native silver, "black Sulphides," Antimonial silver and "Grey Copper." 175 feet tunnel on vein.	....
Venmoerkerke.....	..	....	....	....

White Grouse and

Situated on the head waters of one of the branches of the St. Mary's River. Many locations have

La France

On the E. shore of Kootenay L. Over one hundred

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined.		*Ore Shipments, Particulars of.		Remarks.
		Tons.	Contents or Value.	Tons.	Contents or Value.	

Creek Camp.

further development work was delayed owing to the general depression.

Creek Camp.

...	Lowest assay 220 oz. silver. Assay from 6 inch pay streak 600 oz. silver.	...	...	...	...	
...	One discovery assayed $249, another $400 in gold per ton.	...	...	...	...	

Slocan Lake.

...	Pay streak averages 215 oz. silver and $21 gold. Highest assay 920 oz. silver and $40 gold.	...	...	...	...	Three miles E. of and near the foot of Slocan Lake.

of New Denver.

...	...	...	...	...	...	...

Belt.

on the belt, extending from Slocan Lake near the mouth of Wilson Creek eastwards to the head-
The importance of these ores for mixing with the others of the district to facilitate the smelting
ment work has not been extensive but assays of specimens are said to have yielded from 91 to 1250

...	...	...	...	1¼	232 oz. silver.	
...	Assays from 640 to 3834 oz. silver.	...	...	2½	395 oz. silver.	
...	...	...	...	3	195 oz. silver.	

Red Mountain Subdistrict.

been staked out but although some rich specimens were obtained little or no developments were made.

Creek Subdistrict.

claims located but ore reported to be of low grade.

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine.	Force employed.	Mining Developments.		Mining Plant.
		Shafts.	Tunnels, Drifts, Winzes, &c.	

Fry Creek

Placer Claim..	..	....	Located too late to commence work.	....
Gold-bug........	..	....	....	....

Lardeau and

Although much interest was taken in that part of the district of S. W. Kootenay situated along the disappointing. Twenty-seven miles of new trails have been constructed making a valuable

Great Northern Group..	..	....	Tunnel run for some distance...	....
Wagner Group........	..	....	Vein 20 feet wide. Some development work done.	....
Silver Cup	..	....	4 feet vein being developed.....	....
Abbott Group........	..	....	Considerable work done in the fall.	....
Riverside Claim........	..	....	3 feet ledge of ore. 50 feet tunnel.	....
Black Prince........	..	....	....	....
Gainor Group.	..	....	4 feet vein........	....
Abrahamson Group......	..	....	Considerable work has been done.	....

Goat River and

Locations made, 52; certificates of work, 28. Developments said to have proved the existence of better means of communication to ship the ore to market.

Illecillewaet

There were 31 locations made, 12 being new discoveries, the remainder re-locations of abandoned done in the district; no development.

Glengarry and Sir John Macdonald Claims.	..	....	Large show of ore said to have been located in September.	....

*The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.‡	Ore Mined.		*Ore Shipments, Particulars of		Remarks.
		Tons.	Contents or Value.	Tons.	Contents or Value.	

Subdistrict.

...	...	...	...	...	...	
...	Quartz specimens obtained assaying high in gold.	...	...	...	...	

Duncan Subdistrict.

rivers thus named and many prospectors went there, the results in general seem to have been rather addition to the means of operating the district.

...	110 oz. silver; considerable gold.	...	...	...	...	On N. fork of Lardeau R.
...	110 oz. silver; 70 per cent lead.	...	...	...	...	Near head waters of Healy Creek.
...	600 to 1300 oz. silver.	...	...	...	...	
...	...	...	...	...	...	On a fork of Healy Creek.
...	$17 to $20 in gold.	...	...	...	...	On Trout L.
...	300 to 400 oz. silver.	...	...	...	...	
...	103 oz. silver; $46.65 in gold.	...	...	...	...	12 miles from Trout L.
...	23 to 153 oz. silver; $16 to $53 in gold.	...	...	...	...	

Duck Creek Subdivision.

large bodies of rich ore many tons of which have been mined and are now on the dumps awaiting

Subdivision.

ground. 37 certificates of work were issued. 15 bills of sale were recorded. Only assessment work

...	Specimens, 400 oz. silver; 20 per cent copper; a little gold.	...	...	...	...	20 miles up Fish River.

illustrative data of sundry lots of ore produced, &c.

Name of Claim or Mine.	Force employed.	Mining Developments.		Mining Plant.
		Shafts.	Tunnels, Drifts, Winzes, &c.	

Revelstoke

Locations made, 27 ; certificates of work, 2 ; bills of sale, 25. The majority of locations were

Big Bend Section.......	..	... .	....	... .
French Creek..	..	....	Quartz specimens obtained said to assay well in gold.	....
" [Consolidation Placer Claim.]	..	....	Reported to be takiug out good pay but no returns to hand.	....
" [McCullock Creek]	..	.. ..	Attention is being directed to this creek.	... .
Smith Creek and Goldstream.	..	....	Gold obtained from placer on Goldstream, but cold weather prevented clean up on Smith Creek.	....

* The figures in these columns do not refer to total quantities of ore mined or shipped but give

Milling Plant and Results.	Assays of Specimens and Samples.	Ore Mined.		*Ore Shipments, Particulars of.		Remarks.
		Tons.	Contents or Value.	Tons.	Contents or Value.	

Subdivision.

re-locations of abandoned ground.

......	......	......	......	......	......	26 of the locations were made here.
......	......	......	......	......	......	
......	......	......	......	......	......	
......	......	......	......	......	......	
......	......	......	......	......	$400	

illustrative data o sundry lots of ore produced, &c.

PRECIOUS METALS.

Vancouver Island.

Discovery and development in British Columbia.

The report of the Minister of Mines contains some interesting notes by Mr. Herbert Carmichael, the provincial government analyst, on certain mineral occurrences in the south-western portion of the island, from which the following data have been gleaned :—

Leech River Sub-district.—A good deal of prospecting has been done on the different branches of this river, the best results having been obtained from the West and South Forks, the few samples received from the North Fork proving of little value.

After leaving the slate country on the North Fork hardly any gold is found in the creek and no ledges have been discovered of any value, but some gold has been found on the West Fork that drains the Jordan Meadows.

Koksilah, Jordan and San Juan Rivers.—Gold has been obtained at the headwaters of these rivers, all of which rise in the same range of mountains.

Jordan Meadows.—"Colours" have been found in a bed of red gravel above the meadows at the headquarters of the Jordan River. A prospect hole was sunk some years ago to bed rock, which was found at 15 feet below the surface, but after going through the red gravel no more gold was found, the bed rock proving quite clean. All the gold in the creeks of this district is of a coarse character.

San Juan Sub-district.—Gold has been found in nearly all the streams flowing into the San Juan harbour. There are some good looking quartz ledges between the McDonald and Fleetwood creeks, which flow into the San Juan River near where the Leech River trail strikes it Some quartz veins are said to be at the headquarters of the Gordon River. A $10 gold nugget was found in a small stream flowing into Providence Cove, which led to further prospecting being done, resulting in the locating of several veins of white quartz, whose outcroppings showed small quantities of gold.

Carmanah Light.—Gravel which will give a "colour" to the pan in almost every place tried, is said to exist in large quantities in the neighbourhood of this point on the coast.

Cowichan Lake Sub-district.—Several of the streams flowing into this lake give "colours" of gold, and galena has been found in small quantities about the lake and on the Cowichan River and Nixon Creek.

Alberni sub-district :—

China Creek.—Chinese have worked profitably on this creek, saving the "flour gold" there found. Several claims have been located on

quartz veins at the head of the creek on which a small amount of development has been done. Most of the ore of this district has so far, however, proved refractory, the gold being apparently carried in the pyrites.

PRECIOUS METALS.

Discovery and development in British Columbia.

Texada Island.—It is reported from this place that finds of gold quartz have been made as a result of prospecting work during the season.

ASSAYS OF ORES.

Assays of ores.

The following extracts from the report by Mr. W. Pellew Harvey, on the assay of the ores exhibited by the province at the Chicago Exhibition, is here reproduced in full, as giving interesting and valuable general data regarding the ores of the various mining districts of the province. Various ores are included which would mineralogically be rather ranked as copper minerals, but which can properly be considered in this connection in view of their carrying considerable amounts of the precious metals. The range of Mr. Harvey's investigations covered the assaying and examination of some 200 specimens.

East Kootenay.—From East Kootenay, not including Fort Steele district, there were thirty-five specimens received, some carrying argentiferous lead, others argentiferous copper, and some were quartz, carrying small quantities of silver, with a good sprinkling of gold.

The silver average, taking one with another, was 45·50 oz. per ton.
The gold " " " " 4·30 "

Adding these, we have a result which is exceedingly encouraging, particularly when the fact is kept fully in view that some of the specimens from which the average is obtained should not really be classified as silver bearing at all.

The "silver-lead" ores from this particular district, were such that a smelting company, having opportunities of mixing their purchases, would have no necessity for making any deduction for zinc or other base metals, detrimental to the working of the product.

With the exception of the Monarch ores at Field, the little zinc contained is in nearly every case counterbalanced by the proportion of iron. The ores carrying most zinc are those, as a rule, which could not be concentrated on account of the considerable amount of silver contained in the zinc-blende. There is, however, no silver in the zinc-blende of the Monarch mine.

Gold Ore.—The samples treated were chiefly quartz, and quartz carrying iron and arsenical pyrites. In the majority of the cases the

PRECIOUS METALS.

Assays of ores.

gold was free. This would naturally be the case at the surface the action of the air having converted the original sulphides into oxides, leaving the precious metal, exposed and deposited in the cells vacated by the cubes of sulphurets, now decomposed.

Fort Steele.—The average contents of the silver and gold in the specimens from this camp was not so encouraging as from other parts of East Kootenay, but this may be accounted for by the fact that several samples were sent which should have remained where they were found. To compensate, however, the "North Star" comes in with a 47 oz. silver and 63·47 per cent lead ore. The partial analysis of this ore may be of interest to the smelting men, showing as it does good fluxing properties :

Lead	67·50	per cent.
Iron	6·63	"
Zinc	1·90	"
Antimony	5·41	"
Silver	47·31	oz. per ton.

West Kootenay.

The number of specimens received from the camps in West Kootenay was greatly in excess of that from East Kootenay. They average well in both silver and lead.

Thirteen specimens were received from the section which includes the following well known mines : Best, Great Western, Lucky Jim, Washington, Northern Belle, Monte-Christo, White Water, Wellington, Blue Bird, Reca, Bonanza King, Payne, and Dardanelles.

The silver contained averaged	237	oz. per ton.
The lead " "	58·00	per cent.

with very little detrimental impurities if any. There was a little antimony, and in some cases a small percentage of zinc.

Hot Springs—Eighteen specimens, averaging in silver . . 58 oz. per ton.
" " lead . . 53·00 " cent.

No gold. A few of these were certainly refractory ores, but the majority could easily be smelted with mixing facilities. Sulphide of antimony was present.

Slocan.—The seventeen samples from the Slocan were excellent specimens of galena.

The silver average was	178	oz. per ton.
The lead "	61·00	per cent.

As in the former case, they carry no gold. Any of these ores could be easily reduced. They carry with lead and silver, antimony and iron.

One glance at the averages show one what there is in store for the Slocan. Combining this group with that of the Payne and Dardanelles, etc., I doubt if any mining section of North America can equal these results. PRECIOUS METALS. Assays of ores.

Illecillewaet.—The exhibit from this old mining locality, favourably situated on the main line of the Canadian Pacific Railroad, is an exceptionally good one. There is hardly a sample which could not be classified as high grade. Some of the eight sent, although not quite as rich in silver as the ore from the Slocan, are quite equal in smelting qualities. Clean ores, running over 70 per cent in lead, with the balance sulphur, antimony, and a little silica, are not to be met with every day. These specimens are more than creditable to the contributors and the camp. The Elizabeth, North Star, Red Fox, and Annie, should be particularly mentioned. The Illecillewaet collection is no doubt equal if not superior to any.

The silver contents averaged..........	111 oz. per ton.
The lead "	64·00 per cent.

There was one sample of "peacock copper ore" from the Silver Bow which struck me as being a particularly beautiful specimen, carrying heavy percentages of gold, silver and copper.

Nelson.—Three pieces of quartz containing free gold were treated which came from near Nelson; the exact location not known. The gold average was $60.12 per ton, a fact which should lead to a strict investigation of the reef from which the specimens were obtained.

Toad Mountain.—A few samples only were sent from this camp. There was one fine ferruginous quartz specimen from the Majestic, carrying much free gold. The Silver King, argentiferous copper, with silver 444 oz., and 23.50 per cent copper, requires no further mention. The Dandy sent two specimens, but unfortunately my tests did not come anywhere near the produce generally credited to this ore. It is decidedly refractory.

Trail Creek.—Sixteen specimens composed this exhibit. They contained various quantities of gold, silver and copper. The ore is a yellow sulphide, and should be treated and converted into matte on the spot. The extent of the deposits, and the gold contained, should make these ores valuable apart from copper. I should expect to find nickel in such ore.

Nakusp.—These ores were certainly exceedingly good and particularly clean. Eight made the total sent, all of which were good wet ores.

The silver contents averaged..	85 oz. per ton.
The lead " ..	64·00 per cent.

PRECIOUS METALS.

There is little else to be said of this camp, as the remarks of the Slocan are adapted to it.

Assays of ores.

Lardeau.—From the Lardeau eleven samples were treated. The specimens were very fine with very metallic appearance but in many cases, as the assays will show, they did not carry lead. The concentrator will have to be used freely in this camp, if the surface indications are to be taken as indicating the nature of the deposits. With development, however, we may expect more gold. These specimens are in remarkable contrast with any other argentiferous lead ores of West Kootenay, in containing gold. The Silver Cup was decidedly the leader in value of assay, which ran to 251 oz. silver, and $40 in gold to the short ton. The future treatment of these ores will require much consideration and careful analysis.

Yale.—These, which were chiefly gold ores, were slightly disappointing. The average value for gold is small, but, owing to the extent of the reefs, good results may follow. The writer may add, however, that during a private experience with these ores, he has found them of good average yield, and in one case platinum was discovered.

Kamloops.—But few specimens came from this section; but these were all good. One sample of copper from the "Victoria" was first-class and carried 60 per cent of the metal. The silver-leads were good as "concentrating propositions," and should receive the attention they deserve.

Osoyoos Division.—I was particularly struck with the nature of the exhibits from this district. The ores seem to contain silver, gold, lead and copper, in paying quantities. In one case a heavy specimen of antimony sulphide was met with. The majority of the claims sent gold ore, the best assay amounting to $360 per ton in gold; this was from the Stemwinder. All the ores are concentrating, carrying the precious metals, in association with iron and assencial pyrites, in a quartz gangue. The gold averaged $30 to $60 per ton.

This concludes my remarks on the ores treated. Attention is drawn to the fact that in individual cases the assays are below the generally reputed values. This is sure to happen in a new country, where the general idea is to "boom" everything. The collection of specimens has been reported upon as fairly and conscientiously as possible; and the splendid average in silver, gold, lead and copper—of the specimens forwarded will speak for itself.

Cariboo.—A few specimens came from this pioneer camp. These were mainly sulphurets (iron and arsenic), carrying from one to three ounces of gold to the ton. With the modern methods of gold extrac-

tion, there is every probability that this mining region will more than regain its proud position. PRECIOUS METALS.

Marketing and Smelting.

Marketing and smelting.

So far the sale for these silver-bearing lead and copper ores of the East and West Kootenay districts has been to the smelting establishments of the Western States. The following figures, kindly furnished by one of the owners of the Wellington Mine in the Kaslo sub-district will give an idea of the smelting charges on this class of rich argentiferous galena, &c., for 1893.

The Tacoma smelter allowed 90 per cent of the lead contents at New York quotations, less $1\frac{1}{2}$ cents for duty, and 95 per cent of the silver contents also at New York quotations, less a smelting charge of $9.

The smelter at East Helena allowed the full contents and deducted $23 for smelting charges.

Whilst there are several establishments for treating ores in the district either complete or in course of construction, none were in operation.

The smelters at Golden and Revelstoke have not yet been operated to any extent, but the small sampling plant recently erected at Kaslo meets a want, and when the reduction and concentrating plant at Ainsworth and the smelter at Pilot Bay on Kootenay Lake are completed and put into operation, doubtless much of the product of the mines will find a local market, which will result in a great saving on freight charges.

PYRITES.

PYRITES.

Production.

The production of pyrites was less during 1893, than in 1892, by 1,228 tons and $3,864, as shown by the following figures:—

1887	38,043	tons, valued at	$171,194
1888	63,479	" "	285,656
1889	72,225	" "	307,292
1890	49,227	" "	123,067
1891	67,731	" "	203,193
1892	59,770	" "	179,310
1893	58,542	" "	175,626

The production for 1894 is 40,527 tons, valued at $121,581.

This material is worth about 13 cents per unit for the contained sulphur, which would give a value for the Canadian ore of about $5 in New York per long ton, or about $3 per short ton for its spot value at the mines.

Pyrites.

Production.

The figures given represent the quantities of the mineral shipped or used during the year for acid making. The great bulk of it is shipped to the United States, only a small proportion being used locally at the Capelton acid works of the Nichols Chemical Company and a little also at the Smith's Falls chemical works.

The average sulphur contents of the ore shipped during the year was about 38 per cent.

The reported introduction by many of the United States acid works of the necessary alterations to enable them use pyrites in place of sulphur, should cause an increasing demand for pyrites, and thereby give a proportionately larger market for the Canadian mineral.

Exports and imports.

Exports and Imports.

The exports of pyrites are given by the Customs Department as 26,750 tons, which represents about half of the material known to have been exported. This discrepancy is doubtless due to some of the material having been classed as copper ore owing to the percentage of that metal it carries.

The imports are as follows :—

Pyrites.

Table 1.

Imports : Brimstone or Crude Sulphur.

Fiscal Year.	Pounds.	Value.
1880	1,775,489	$27,401
1881	2,118,720	33,956
1882	2,375,821	40,329
1883	2,336,085	36,737
1884	2,195,735	37,463
1885	2,248,986	35,043
1886	2,922,043	43,651
1887	3,103,644	38,750
1888	2,048,812	25,318
1889	2,427,510	34,006
1890	4,440,799	44,276
1891	3,601,748	46,351
1892	4,769,759	67,095
1893	6,381,203	77,216
1894	5,845,463	61,558

Salt.

SALT.

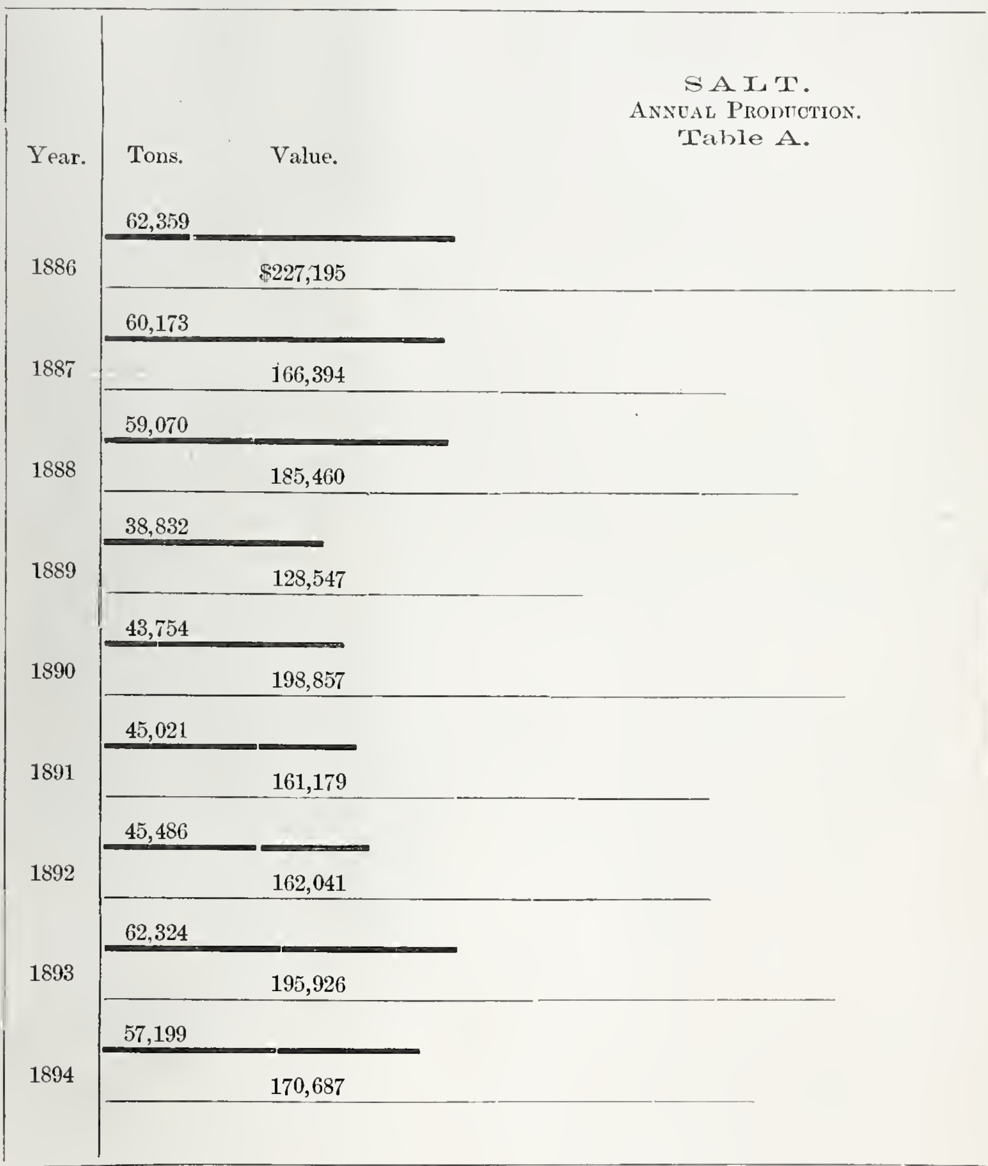
n

The production of salt for 1893 was as follows :—

Land salt	2,355	tons,	worth	$5,658
Coarse "	12,680	"	"	38,575
Fine "	42,497	"	"	129,275
Dairy "	4,792	"	"	22,418
Total	62,324	"	"	$195,926

The annual production during past years will be found graphically represented in table A, from which it will be seen that whilst there was a yearly decrease from 1886 to 1889, there has been since then a small but steady increase, which has brought the figures of production up to what they were in 1886. The production during 1894 was 57,199 tons valued at $170,687. Salt. Production.

The figures of exports and imports compiled from data provided by the Customs Department will be found in the following tables Nos. 1, 2 and 3 :—



SALT.

Exports and imports

SALT.

TABLE 1.

EXPORTS.

Year.	Bushels.	Value.
1880	467,641	$46,211
1881	343,208	44,627
1882	181,758	18,350
1883	199,733	19,492
1884	167,029	15,291
1885	246,794	18,756
1886	224,943	16,886
1887	154,045	11,526
1888	15,251	3,987
1889	8,557	2,390
1890	6,605	1,667
1891	5,290	1,277
1892	2,000	504
1893	4,940	1,267
1894	4,639	1,120

SALT.

TABLE 2.

IMPORTS: SALT PAYING DUTY.

Fiscal Year.	Pounds.	Value.
1880	726,640	$ 3,916
1881	2,588,465	6,355
1882	3,679,415	12,318
1883	12,136,968	36,223
1884	12,770,950	38,949
1885	10,397,761	31,726
1886	12,266,021	39,181
1887	10,413,258	35,670
1888	10,509,799	32,136
1889	11,190,088	38,968
1890	15,135,109	57,549
1891	15,140,827	59,311
1892	18,648,191	65,963
1893	21,377,339	79,838
1894	15,867,825	53,336

SALT.

TABLE 3.

IMPORTS: SALT NOT PAYING DUTY.

Salt. Exports and imports.

Fiscal Year.	Pounds.	Value.
1880	212,714,747	$400,167
1881	231,640,610	488,278
1882	166,183,962	311,489
1883	246,747,113	386,144
1884	225,390,121	321,243
1885	171,571,209	255,719
1886	180,205,949	255,359
1887	203,042,332	285,455
1888	184,166,986	220,975
1889	180,847,800	253,009
1890	158,490,075	252,291
1891	195,491,410	321,239
1892	201,831,217	314,995
1893	191,595,530	281,462
1894	196,668,730	328,300

DISCOVERY AND DEVELOPMENT.

Discovery and development.

With regard to the industry, there is nothing new and the permanent features have been dealt with in previous reports.

The figures of production for 1893, given above, represent the product of some 20 operators in Ontario employing, according to the returns received, over 200 men. Probably about half of this number were employed in the actual manufacture of the salt, the remainder working in the cooper shops, usually connected with salt works, making the necessary packages for the salt.

Except for a very small amount produced in New Brunswick, operations were as formerly confined to evaporating the brines pumped from the numerous wells throughout the Western Ontario salt field which borders on Lake Huron. Full descriptions have been given of these in previous reports, which it will be unnecessary to repeat here.

STRUCTURAL MATERIALS.

Structural materials.

Building stone.

Building Stone.—No returns were asked for nor received for the year's production of building stone. There was, however, a much larger production than in previous years, due to the large amount of building operations in the larger cities. According to the report of the Bureau of Mines of Ontario for the year ending 31st October,

STRUCTURAL MATERIALS.

Building stone.

1893, there was produced in that province building stone of various grades as follows :—

Dimension stone,	c. ft.	1,400,000,	valued at	$260,000
Heads and sills	"	44,700	"	21,000
Coursing stone	sq. yds.	170,000	"	180,000
Rubble, &c.	c. yds.	410,000	"	260,000
				$721,000

According to figures published in past reports of this division, Ontario has annually afforded about two-thirds of the total production. Assuming this to have been the case, there will be seen to have been a total output throughout the Dominion of about $1,100,000.

No further information regarding production or development is at hand.

The following tables of exports and imports are taken from the reports of the Customs Department and are self-explanatory.

STRUCTURAL MATERIALS,

TABLE 1.

EXPORTS OF STONE AND MARBLE, WROUGHT AND UNWROUGHT.

Province.	Wrought.		Unwrought.	
	1893.	1894.	1893.	1894.
	$	$	$	$
Ontario	4,558	17,497	2,203	16,250
Quebec	2,843	1,761	3,200	1,883
Nova Scotia	819	3,185	385	7,525
New Brunswick	882	133	3,543	5,686
British Columbia	....	....	3,201	2,786
Totals	,102	22,576	12,532	34,130

The foregoing table, probably, includes also a small quantity of granite.

STRUCTURAL MATERIALS.

Building stone.

STRUCTURAL MATERIALS.

TABLE 2.

IMPORTS OF BUILDING STONE.

Fiscal Year.	Value.
1880	$ 35,970
1881	58,149
1882	33,623
1883	35,061
1884	51,088
1885	30,491
1886	41,675
1887	54,368
1888	86,373
1889	100,314
1890	132,155
1891	170,890
1892	95,550
1893	56,510
1894	52,908

STRUCTURAL MATERIALS,

TABLE 3.

IMPORTS OF MANUFACTURES OF STONE OR GRANITE, N.E.S.

Fiscal Year.	Value.
1880	$29,408
1881	36,877
1882	37,267
1883	45,636
1884	45,290
1885	39,867
1886	41,984
1887	41,829
1888	47,487
1889	61,341
1890	84,396
1891	61,051
1892	39,479
1893	49,323
1894	49,510

Structural materials.

According to the foregoing statistics, there will be found, during 1893, to have been a market for building stone in Canada of $1,159,069, as follows:

Building stone.

Production estimated	$1,100,000	
Imports, building stone	56,510	
" stone and granite (consisting principally of structural stone)	49,323	
		$1,205,833
Less.		
Exports, wrought stone	$ 9,102	
" unwrought stone	37,662	
		46,764
		$1,159,069

This amount shows an increase over figures obtained in the same way for 1892, of $469,317.

Marble.

Marble.—The production of marble, according to direct returns received at this office, is altogether that of the province of Ontario and amounted to 590 tons valued at $5,100, showing an increase in value over the previous year of $1,500, whereas the quantity was increased 250 tons.

The production during past years was as follows:

1886	501	tons,	value,	$9,900
1887	242	"	"	6,224
1888	191	"	"	3,100
1889	83	"	"	980
1890	780	"	"	10,776
1891	240	"	"	1,752
1892	340	"	"	3,600
1893	590	"	"	5,100

No returns of production were received for 1894.

In the following table are given the imports since 1880. No exports are reported as such, though there may be a small quantity included in table 1.

STRUCTURAL MATERIAL.

Marble.

STRUCTURAL MATERIALS.

TABLE 4.

IMPORTS OF MARBLE.

Fiscal Year.	Value.
1880	$ 63,015
1881	85,977
1882	109,505
1883	128,520
1884	108,771
1885	102,835
1886	117,752
1887	104,250
1888	94,681
1889	118,421
1890	99,353
1891	107,661
1892	106,268
1893	96,177
1894	94,657

Granite.

Granite.—The production of granite during 1893 was 22,521 tons, valued at $94,393, showing a decrease in quantity compared with the previous year, yet in value there is seen to have been an increase of $5,067.

The production by provinces was as follows :—

Ontario	2,642	tons,	valued at	$ 4,951
Quebec	10,340	"	"	46,375
Nova Scotia	3,184	"	"	14,898
New Brunswick	1,625	"	"	17.300
British Columbia	4,730	"	"	10,869

During past years the annual production was as follows :—

1886	6,062	tons,	valued at	$ 63,309
1887	21,217	"	"	142,506
1888	21,352	"	"	147,305
1889	10,197	"	"	79,624
1890	13,307	"	"	65,985
1891	13,637	"	"	70,056
1892	24,302	"	"	89,326
1893	22,521	"	"	94,393
1894	16,392	"	"	109,936

The exports and imports, if any, are not available, being included in the figures shown in tables 1 and 3.

Slate.

Slate.—This industry is showing a steady growth several new quarries having been opened up during 1893. The production during

STRUCTURAL MATERIALS.

1893 was 7,112 tons, valued at $90,825, an increase over the previous year of 1,932 tons and in value of $2,175.

Slate.

The production during 1894 was valued at $75,550.

The following tables are of exports and imports during the present and past years :—

STRUCTURAL MATERIALS.

TABLE 5.

EXPORTS OF SLATE.

Year.	Tons.	Value.
1884	539	$6,845
1885	346	5,274
1886	34	495
1887	27	373
1888	22	475
1889	26	3,303
1890	12	153
1891	15	195
1892	87	2,038
1893	178	3,168
1894	187	3,610

STRUCTURAL MATERIALS.

TABLE 6.

IMPORTS OF SLATE.

Fiscal Year.	Value.
1880	$21,431
1881	22,184
1882	24,543
1883	24,968
1884	28,816
1885	28,169
1886	27,852
1887	27,845
1888	23,151
1889	41,370
1890	22,871
1891	46,104
1892	50,441
1893	51,179
1894	29,267

Flagstones.

Flagstones.—The production of flagstones during 1893 was as in previous years principally that of Quebec and Nova Scotia, from which provinces, only, were returns received. These show the production to have been 40,500 square feet valued at $3,487, an increase over 1894 of 26,800 square feet and in value $2,118.

During the past seven years the annual production has been as follows : STRUCTURAL MATERIALS.

Flagstones.

1887—116,000 feet, valued at	$11,600
1888— 64,800 " "	6,580
1889— 14,000 " "	1,400
1890— 17,865 " "	1,643
1891— 27,300 " "	2,721
1892— 13,700 " "	1,869
1893— 40,500 " "	3,487

In 1894 the production was 152,700 square feet valued at $5,298.

No exports of flagstones are reported as such ; the imports are given below :

STRUCTURAL MATERIALS.

TABLE 7.

IMPORTS OF FLAGSTONES.

Fiscal Year.	Tons.	Value.
1881	23	$ 241
1882	90	848
1883	10	99
1884	137	1,158
1885	205	1,756
1886	1,602	9,443
1887	1,316	10,966
1888	2,642	21,077
1889	1,669	15,451
1890	5,665	48,995
1891	3,770	36,348
1892	1,571	15,048
1893	884	8,500
1894	218	2,429

Cement.

Cement.—During 1893, there was a production of natural and Portland cement amounting to 158,597 barrels valued at $194,015, showing an increase in quantity over the previous year of 51,189 barrels, the increase in value being $46,352.

In 1893 the production of both natural and Portlant cement was :

Natural cement,	126,673 barrels, valued at	$130,167
Portland "	31,924 "	63,848

STRUCTURAL MATERIALS.

Cement.

For the past seven years there has been an annual production of cement as follows :—

1887	69,843	bls. valued at	$	81,909
1888	50,668	" "		35,593
1889	90,474	" "		69,790
1890	102,216	" "		92,405
1891	93,473	" "		108,561
1892	107,408	" "		147,663
1893	158,597	" "		194,015

During 1894 the production was 108,142 barrels, valued at $144,637,

No data regarding recent developments are at hand. The following tables show the exports and imports of all classes of natural and Portland cements :

STRUCTURAL MATERIALS.

TABLE 8.

EXPORTS OF CEMENT.

Province.	1891.	1892.	1893.	1894.
Ontario	$2,534	$399	$ 718	$339
Quebec	283	539	386	42
Nova Scotia	64	....	68	101
Totals	$2,881	$938	$1,172	$482

STRUCTURAL MATERIALS.

TABLE 9.

IMPORTS OF CEMENT IN BULK OR BAGS.

Fiscal Year.	Bushels.	Value.
1880	65	$ 28
1881	579	298
1882	386	86
1883	1,759	548
1884	4,626	1,236
1885	4,598	1,315
1886	6,808	1,851
1887	5,421	1,419
1888	23,919	5,787
1889	32,818	10,668
1890	21,055	5,443
1891	11,281	2,890
1892	14,351	3,394
1893	12,534	2,909
1894	9,027	2,618

STRUCTURAL MATERIALS.

TABLE 10.

IMPORTS OF HYDRAULIC CEMENT.

Fiscal Year.	Barrels.	Value.
1880	10,034	$ 10,306
1881	7,812	7,821
1882	11,945	13,410
1883	11,659	13,755
1884	8,606	9,514
1885	5,613	5,396
1886	6,164	6,028
1887	6,160	8,784
1888	5,636	7,522
1889	5,835	7,467
1890	5,440	9,048
1891	3,515	6,152
1892	2,214	2,782
1893	4,896	8,060
1894	1,054	985

STRUCTURAL MATERIALS.

TABLE 11.

IMPORTS OF PORTLAND CEMENT.

Fiscal Year.	Barrels.	Value.
1880	....	$ 55,774
1881	....	45,646
1882	....	66,579
1883	....	102,537
1884	....	102,857
1885	....	111,521
1886	....	120,398
1887	102,750	148,054
1888	122,402	177,158
1889	122,273	179,406
1890	192,322	313,572
1891	183,728	304,648
1892	187,233	281,553
1893	229,492	316,179
1894	224,150	280,841

STRUCTURAL MATERIALS.

Cement.

Roofing Cement.—There was a production of roofing cement during 1893, of 951 tons valued at $5,441, showing a marked increase in quantity, yet the value fell off to the extent of $6,559. The production during past years was as follows :—

1890	1,171 tons,	valued at	$ 6,502
1891	1.020	" "	4,810
1892	800	" "	12,000
1893	951	" "	5,441
1894	815	" "	3,978

Lime.

Lime.—No returns being asked for by this office we are unable to give the exact figures of production for 1893.

The production in Ontario, according to the report of the Bureau of Mines of that province, for the year ending 31st October, 1893, was 2,700,000 bushels valued at $364,000. In past years Ontario has been found to produce about two-fifths of the total output; assuming this to be the case, there was therefore an approximate production throughout Canada of 6,750,000 bushels valued at about $900,000.

The exports and imports are given in the following tables :

STRUCTURAL MATERIALS.

TABLE 12.

EXPORTS OF LIME AND CEMENT.

Province.	1893.		1894.	
	Lime.	Cement.	Lime.	Cement.
Ontario	$16,494	$ 718	$13,208	$339
Quebec	25,947	386	30,294	42
Nova Scotia	4,710	68	3,482	101
New Brunswick	36,411	....	33,830	....
Prince Edward Island	....	....	3	....
Manitoba	....	....	....	....
British Columbia	3,061	....	2,853	....
Totals	$86,623	$1,172	$83,670	$482

STRUCTURAL MATERIALS.
LIME.

STRUCTURAL MATERIALS.
TABLE 13.
IMPORTS OF LIME.

Fiscal Year.	Barrels.	Value.
1880	6,100	$ 6,013
1881	5,796	4,177
1882	5,064	5,365
1883	7,623	9,224
1884	10,804	11,200
1885	12,072	11,503
1886	11,021	9,347
1887	10,835	8,524
1888	10,142	7,537
1889	13,079	9,363
1890	8,149	5,360
1891	6,259	4,273
1892	6,132	4,241
1893	6,879	4,917
1894	6,766	4,907

Building brick.

Building Brick.—It is impossible to give the exact production of building brick for 1893, as no returns were asked for. According to the report of the Bureau of Mines of Ontario, there was a production in that province of common brick of 162,350,000 valued at $932,500, and of plain and fancy bricks of 21,581,000, the latter with an average value of $10 per 1000 or $215,810. This would give Ontario a production of 183,931,000 valued at $1,148,310. It has been found that in past years Ontario produced about five-eighths of the total output of the Dominion; assuming this to be the case there would be a production approximately of 290,000,000 valued at $1,800,000.

The following tables illustrate the exports and imports of building brick :—

STRUCTURAL MATERIALS.
TABLE 14.
EXPORTS OF BRICKS.

Province.	1890.		1891.		1892.		1893.		1894.	
	M	Value	M	Value	M	Value	M	Value	M	Value
Ontario	715	$3,449	229	$1,039	1,347	$8,784	552	$2,462	280	$1,257
Quebec	....	....	....	...	353	1,566	2,189	17,969	68	917
Nova Scotia	19	156	14	94	252	1,662	2,561	16,449	489	3,252
New Brunswick	....	....	....	....	10	170	767	7,185	258	1,979
P. E. Island	15	157	3	30	1	10	....	....	....	....
British Columbia	....	....	....	....	....	....	4	45	....	....
Totals	749	3,762	246	1,163	1,963	12,192	6,073	44,110	1,095	7,405

STRUCTURAL MATERIALS.

Building brick.

STRUCTURAL MATERIALS.

TABLE 15.

IMPORTS OF BUILDING BRICK.

Fiscal Year.	Value.
1880	$ 2,067
1881	4,281
1882	24,572
1883	14,234
1884	20,258
1885	14,632
1886	5,929
1887	2,440
1888	20,720
1889	24,585
1890	12,500
1891	9,744
1892	5,075
1893	14,108
1894	18,320

Terra cotta.

Terra Cotta.—During 1893, the production of terra-cotta, both structural and ornamental, amounted to $55,704 of which Ontario afforded $30,704 and Quebec $25,000.

During past years the production was as follows :—

1888	$ 49,800
1889	Not available.
1890	90,000
1891	113,103
1892	97,239
1893	55,704
1894	65,600

Drain tile.

Drain Tile.—The production of drain tile in Ontario according to the report of the Bureau of Mines of that province was, during 1893, 17,300 thousands valued at $190,000 this would represent about nine-tenths of the total production of the Dominion, which would therefore be approximately 190,000 thousands having a value of about $200,000.

No imports or exports are reported as such, the imports, if any, are included with those of sewer pipe.

Sewer Pipe.—The production of sewer pipe during 1893, was $350,000, showing a slight decrease compared with 1892. In 1894 the production was valued at $250,325.

The production during past years was as follows :— STRUCTURAL MATERIALS. Drain tile.

1888	$266,320
1889	Not available.
1890	348,000
1891	227,300
1892	367,660
1893	350,000
1894	250,325

The following table illustrates the imports of sewer-pipe included with those of drain tiles :—

STRUCTURAL MATERIALS.

TABLE 16.

IMPORTS OF DRAIN TILES AND SEWER PIPES.

Fiscal Year.	Value.
1880	$ 33,796
1881	37,368
1882	70,065
1883	70,699
1884	71,755
1885	69,589
1886	57,953
1887	71,203
1888	101,257
1889	83,215
1890	77,434
1891	87,195
1892	59,537
1893	39,001
1894	24,625

Pottery.—The production of pottery during 1893 amounted to $213,186 ; showing a decrease when compared with 1892. The production according to provinces was :— Pottery.

Ontario	$115,000
Quebec	72,236
Nova Scotia	8,950
New Brunswick	10,000
Prince Edward Island	3,000
Manitoba	4,000

STRUCTURAL MATERIALS.

Pot

It is supposed that there was a small production in British Columbia, though of this we have no returns.

During past years the annual production was as follows :—

1888	$ 27,750
1889	Not available.
1890	195,242
1891	258,844
1892	265,811
1893	213,186
1894	162,144

No exports are reported as such ; the only trade statistics available are the imports of earthenware given below :—

STRUCTURAL MATERIALS.

TABLE 17.

IMPORTS OF EARTHENWARE.

Fiscal Year.	Value.
1880	$322,333
1881	439,029
1882	646,734
1883	657,886
1884	544,586
1885	511,853
1886	599,269
1887	750,691
1888	697,082
1889	697,949
1890	695,206
1891	634,907
1892	748,810
1893	709,737
1894	695,514

Sand and Gravel.—No statistics of production are available as no returns were received bearing upon this somewhat uncertain industry; the following tables give, however, some information regarding exports and imports :— STRUCTURAL MATERIALS. Sand and gravel.

STRUCTURAL MATERIALS.

TABLE 18.

EXPORTS OF SAND AND GRAVEL.

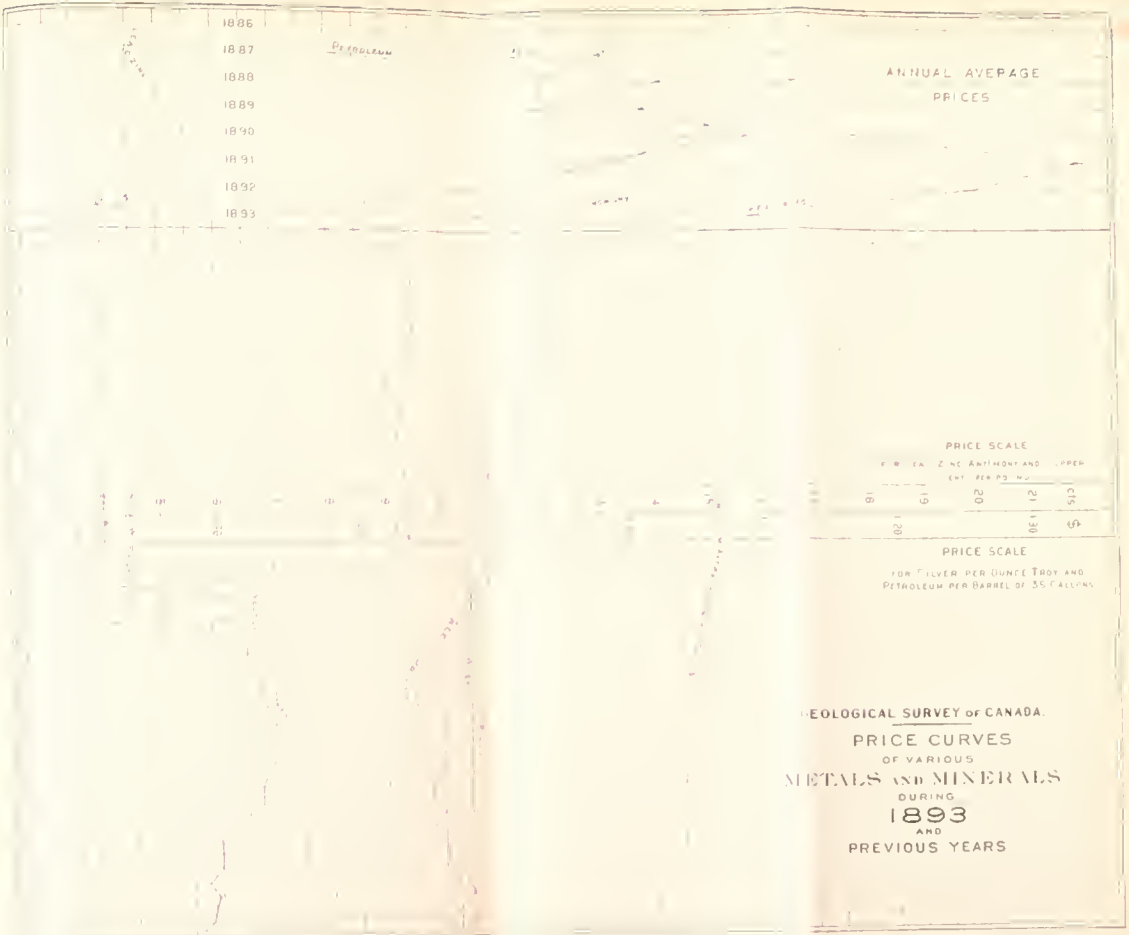
Province.	1892.		1893.		1894.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Ontario...........	297,406	$84,311	328,707	$121,237	323,679	$84,223
Quebec	25	30	....	....	....	....
Nova Scotia	175	703	10	9	401	1,605
New Brunswick......	150	150	383	525	572	1,104
Manitoba............	72	42	....	....	....	....
British Columbia.....	50	93	16	24	4	8
Total....... ...	297,878	$85,329	329,116	$121,795	324,656	$86,940

STRUCTURAL MATERIALS.

TABLE 19.

EXPORTS OF SAND AND GRAVEL.

Year.	Tons.	Value.	Year.	Tons.	Value.
1877...	11,998	$ 2,151	1886	124,865	$ 24,226
1878..	50,140	8,381	1887....... ...	180,860	30,307
1879	46,999	9,438	1888.............	260,929	38,398
1880.	53,951	11,177	1889........... .	283,044	52,647
1881............	58,693	15,129	1890............	342,158	65,518
1882........	60,158	16,218	1891.	243,724	59,501
1883.	55,346	14,065	1892.	297,878	85,329
1884	73,741	19,978	1893.............	329,116	121,795
1885............	110,661	22,878	1894..	324,656	86,940



1886
1887
1888
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ABBREVIATIONS.

B.C.	Province of British Columbia.	N.W.T.	North-west Territory.
M.	Province of Manitoba.	O.	Province of Ontario.
N.B.	Province of New Brunswick.	P.E.I.	Prince Edward Island.
N.S.	Province of Nova Scotia.	Q.	Province of Quebec.